Histological Investigation of Late Neolithic Agriculturist Settlement in Northern Jordan

Rula Nuri Shafiq

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Histological Investigation of Late Neolithic Agriculturist Settlement in Northern Jordan

Rula Nuri Shafiq

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ABSTRACT

WZ200 is a late Neolithic farmstead settlement with the main occupational levels clustered at 6700 to 6300 bp. The skeletal remains of twelve individuals: three adults and nine subadults, were recovered during three excavation seasons, 1987, 1990 and 1992. Six individuals out of nine whose skeletal remains are complete to allow analysis had several pathological conditions. Macroscopic and microscopic methodologies were implemented in the study of nine individuals. Eleven histological samples were taken from seven individuals for pathological and diagenesis analysis. The results of such studies revealed a case of treponematosis, possibly 'bejel', where histological and microscopical characteristic within tibial diaphyses indicated the case. Pathological changes indicative of anemic disorders were found in four individuals as proliferation of the endosteal surface of the cortical limb bones. Dental enamel hypoplasia was high in frequency within this sample indicating several periods of ill health. The pathological conditions found do not indicate dependence on population density, as needed for the transmission of infectious diseases such as tuberculosis, which was not found in this population. Even though the rate of pathological conditions found within this small and biased sample are high, still the health of this population is considered to be good; since the subadult bodies resisted the health disorders for some time to allow traces left in the skeleton system as a record.

KEYWORD

Treponematosis, Bejel, Anemia, Polster, Grenzstreifen, Diagenesis, Histology, Late Neolithic, Wadi Ziqlab, Jordan.

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CHAPTER ONE: 1.0 INTRODUCTION

1.0 INTRODUCTION

1.1 Introduction:

Human burials are one of the cultural components that are frequently discovered in archaeological excavations. The presence of human burials within or outside the boundaries of an archaeological settlement is not a mere coincidence. **It** is clear fact, that the people who built the settlements' architectural elements are the same people who lived in them, and whose skeletal remains are most likely buried in the settlements' associated graves. Therefore, the grave with- its cultural objects and the skeletal remains enclosed are two major elements requires consideration when attempting to interpret the cultural aspects of an archaeological settlement.

The Near East region witnessed a continued occupation from the Upper Palaeolithic period (ca. 40,000 B.P.) (Bar-Yosef 1987) to Roman and modem-day settlements. The Neolithic period in Jordan is a period that witnessed an increase in human populations and more dependence on agriculture and animal domestication (Bar- Yosef 1992). The north-west area of Jordan contains the remains ofthe late Neolithic site of Wadi Ziqlab 200 (WZ200). WZ 200 is a farmstead settlement with the main occupational levels clustered at 6700 to 6300 bp, (bp indicates radiocarbon years, while calibrated dates are in Be) (Banning *et al.* 1994). These dates put the site in the late Neolithic and

transition to the Chalco lithic period. WZ200 was occupied for several hundred years; architectural remains and human burials were uncovered during three seasons of excavation (Banning 1995).

The skeletal remains of eleven individuals were recovered from the site during three field seasons: 1987, 1990 and 1992. These remains are the main focus of this dissertation and are on loan from Dr. E. B. Banning, the Director of the Wadi Ziqlab Project in Jordan, and a Professor of Archaeology at the University of Toronto, Canada.

The aims of the study are the analysis of the skeletal remains of the eleven individuals. The study will be address the archaeological context of WZ200, its cultural sequence tying the graves together with the architectural structures of the site. Macroscopic analysis is used to provide a detailed analysis of the age at death, determination of sex, estimation of living stature, assessment of dental health, and pathological examination of bone lesions. Microscopic analysis of several of the remains using data collected at the University of Gottingen, Germany, under the supervision of Dr. Dr. Michael Schultz, Professor of Anatomy at the Zentrum Anatomie, is used to determine state of micro preservation (diagenesis) of the bone matrix, and diagnosis of pathological conditions on a microscopic level. These combined analyses will allow a discussion of the differential diagnosis of the pathological conditions and the interpretations of these lesions from an archaeological standpoint putting them in the context of agriculture in the Near East, and its consequences on the health.

In Jordan, the disciplines of osteology, paleopathology and funerary archaeology are seldom practised as one comprehensive study of skeletal remains within archaeological sites. The three fields of study are still in their early stages of introduction into archaeological research in Jordan. Thus, analysis of any skeletal remains in Jordan is not considered as a priority, and often the remains are discarded once excavated. The importance of the study of WZ200 skeletal remains in this dissertation can be considered as one of the very few comprehensive studies that have been undertaken for skeletal remains from Jordan. The aim of this study is to incorporate the burials and their mortuary treatment with their archaeological context.

1.2 Historical Background:

The Neolithic age in the Near East has a span of three thousand years, as it starts around 8300 BC and extends until *5000/4800* BC when the early Chalco lithic period begins. The Neolithic period is divided into two sections: pre-pottery Neolithic A-B dated between 8300 to *6000/5800* BC, and pottery Neolithic dated between *600015800* to *500014800* BC (Ben-Tor 1992:2). The Neolithic age witnessed the beginning of a new era in human history, in which agriculture and animal domestication were being practised. Prior to this period, there was dependence on hunting wild animals such as deer, and the gathering of wild seeds and fruits (Bar-Yosef 1992). The Natufian culture existed between 10050 to 8550 BC, portrays the first horticulture practised in the Near East. The Natufians were practising hunting with some dependence on cultivation of cereals (Banning 1995).

The pre-pottery Neolithic A-B periods are considered the beginning of 'farmer-hunter societies' (A), and the establishment of 'farmer-pastoral villages' (B). The pottery Neolithic period encompassed the manufacture of pottery (Bar- Y osef 1992) and an increase in human populations was evident from the rise in room numbers in the settlements. The remains of four major kinds of domesticated animals are found at archaeological sites in the Near East: sheep, goat, cattle and pigs (Moore 1985).

Mortuary treatment for the preceding Natufian culture in the Near East shows a social distinction between interments. Social difference was portrayed in the burial position, either as extended or flexed. Extended burials were located in caves and flexed burials were found in terrace areas associated with certain burial goods, such as dentalium shell, indicative high status (Wright 1978).

The pre-pottery Neolithic A-B at sites in Jordan, like the large settlement at Ain Ghazal, indicate social distinction in the treatment of interments. Burial was conducted in three different locations and each indicated a certain social status for the interments: (1) Underneath plastered house floors in a flexed position, without the cranium but leaving the mandible, and with few or no grave goods (Figure -1-); usually adult remains had this kind of treatment indicating a higher status, (2) between house walls, infants remains were found, suggesting a ritual behaviour (Rollefson *et al.* 1992), and (3) adults and adolescents were buried in 'trash deposits', with their skulls intact and in different burial positions indicating lower status (Figure -2-). Removing the skull while leaving the mandible was done after body decomposition, which allowed separation of the skull. The skulls were later plastered to express facial features of the deceased and

placed in house structures, symbolising a form of cult behaviour. This tradition appears to have been discontinued by the end of the pre-pottery Neolithic B period (Rollefson *et al.* 1992). Interments of the next pottery Neolithic period were buried with their skulls and sometimes outside settlement boundaries (Bar- Yosef 1992).

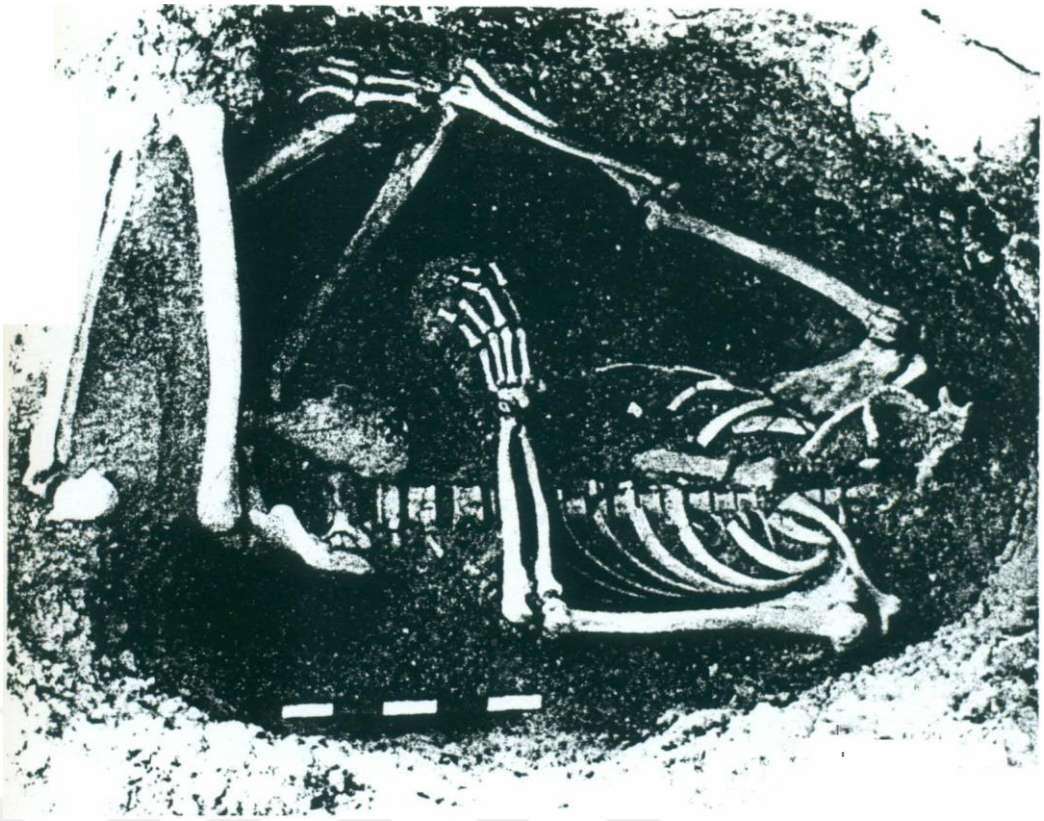


FIGURE 1: A pre-pottery Neolithic burial of an adult indicating high status (Rollefson *et al. 1992:464).*

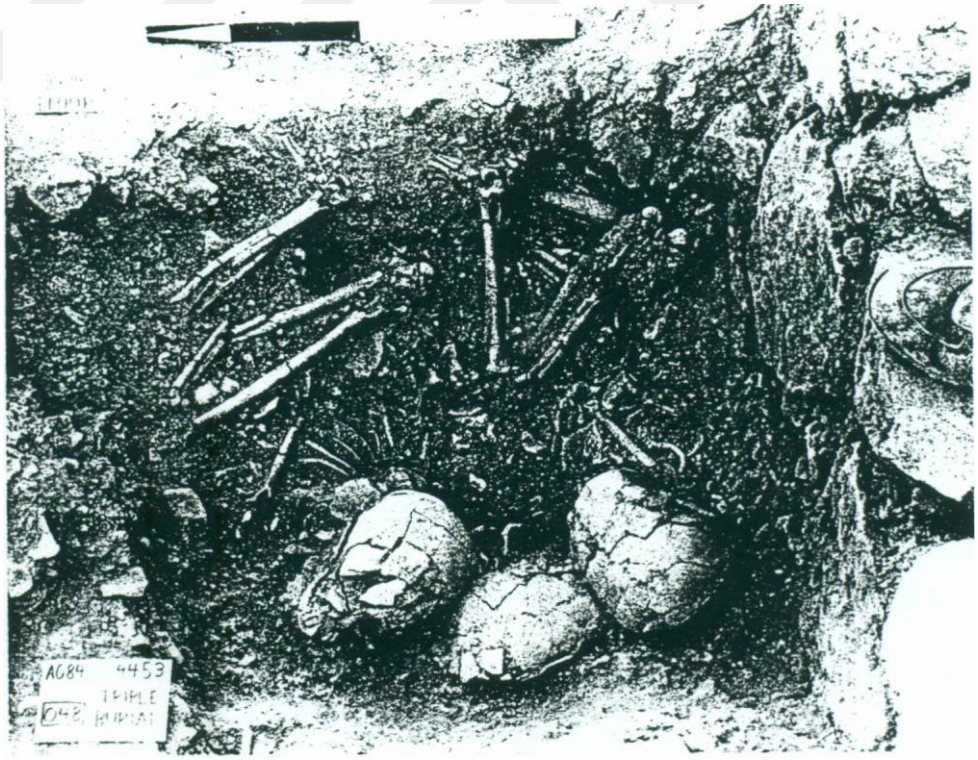


FIGURE 2: A pre-pottery Neolithic burial of adults and adolescents placed in 'trash deposited' with intact skulls indicating lower status (Rollefson *et al*. 1992:465),

CHAPTER TWO: 2.0 MATERIALS

2.0 MATERIALS

2.1 Description of Wadi Ziqlab 200:

Wadi Ziqlab 200 is located to the north-west side of the Jordan Valley, within the drainage basin of the Ziqlab valley area. The main levels of the site are clustered at 6700 to 6300 bp (Banning *et ale* 1994), chronologically putting the site in the late phases of the pottery Neolithic period. The site was discovered in 1987 during a survey conducted along river terraces and stream banks in the Ziqlab area. The Neolithic populations preferred these river terraces as settlement areas because of their close location to permanent water springs and to the quarry areas of flint. Rich in water and vegetation, these terraces became the migration route for both humans and their animals between the warm Jordan valley and the high cooler mountains (Banning 1995).

In 1987, while conducting survey trenches along stream terraces, one of the cist burials of WZ 200 was discovered (Banning *et al.* 1989). Since the result of the trenches excavated were encouraging, two excavation seasons followed in 1990 and 1992. The results of the three seasons revealed that WZ 200 was a small farmstead occupied for several hundred years (Banning 1995). WZ 200 is located on a gently sloping alluvial terrace, located between deep limestone slopes. The slopes surround the site from the

north, south, and east, with some reaching a height of 150 m. The farmstead was situated between two stream channels, and in close proximity to a permanent spring during the Neolithic, which has dried up more recently (Banning *et al.1992).*

The farmstead architecture consist of seven structures, but probably had three complexes at different times. WZ 200 was arranged into several rooms built with limestone wails, grain silos, terrace wails, and a number of pits and cist graves. These structures indicate that WZ 200 had a sequence of farmstead occupation for a period of several hundred years. Thus, from the size of each farmstead sequence, it appears that the total number of inhabitants at one time was probably around twenty individuals (Banning 1995). Figure -3- is a plan view of the whole site with architectural features exposed during the 1987, 1990 and 1992 seasons.

The cultural activities of the people living at WZ 200 are portrayed through the remains of pottery jars and stone tools. Pottery was of local manufacture and sherds were scattered in almost all levels of the site. One pot was decorated with fmgemail impressions. The large numbers of flint sickle blades with a sheen (shiny edge as a result of use) indicate that the inhabitants were harvesting plants on a regular basis on the surrounding hills. Evidence of pottery storage jars, storage bins (silos), and grinding stones ail were used in the preparation of plant remains and their storage. The people of WZ 200 were domesticating animals for consumption, and the skeletal remains of different species were found: goat, sheep, and pigs. Hunting was not intensively practised since only one projectile point was found at the site, indicating great reliance on farming and animal husbandry (Banning *et al.* 1992, Banning 1995).

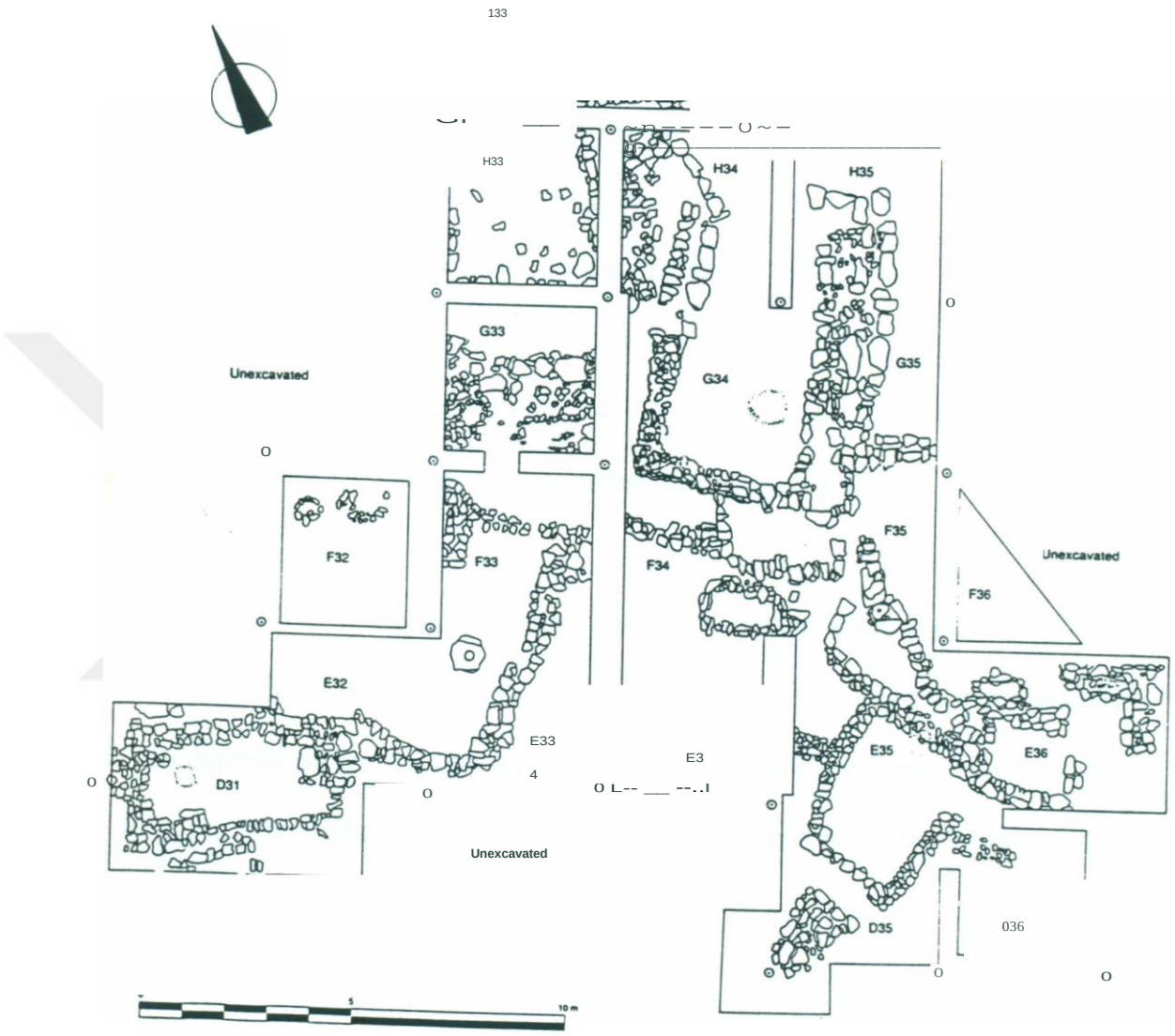


FIGURE 3: Plan view of WZ200 showing architectural structure excavated during seasons 1987, 1990 and 1992 *(Banningetal.* 1994:153).

2.2 Description of the Burials:

The results of three excavation seasons have revealed the skeletal remains of eleven individuals buried within the settlement structure of WZ 200. The eleven individuals are distributed within eight primary graves of three different types: cist graves, surface graves, and a single storage bin grave. The burials do not have the same chronological dating, and the eleven individuals were buried at different times during the several hundred years of site occupation (Banning, pers. comm. 1996). Figure -4- is a site plan showing the location of each grave within the site. Table -1- is a summary of the burials and the eleven individuals, indicating their basic features. The burials are identified with numbers according to their location in the site grid system. The following is a description of each of the graves according to Table 1.

Grave 133: 133 is a cist burial discovered in the 1987 season when trench A uncovered the cap-limestone slabs that covered it. The 133 grave was cut deep into the earlier Kebaran deposits of the site, and against limestone bedrock that formed the west edge of the grave. The north, south and east edges were constructed from large limestone slabs that carried the covering capstones. The spaces between the capstones were not sealed to prevent any leakage of rain and soil into the burial, thus the burial was filled with very fine soil. The deposited skeletal remains were of two adults that were poorly preserved and not complete, locus 005. The large size of the grave indicated that the burial position of the two adults might be extended with their heads placed at the east end near a group of pots. 133 is the only grave of the eight to have a set of burial goods which were "a cluster of broken pottery and, at a depth of 1.5m, a

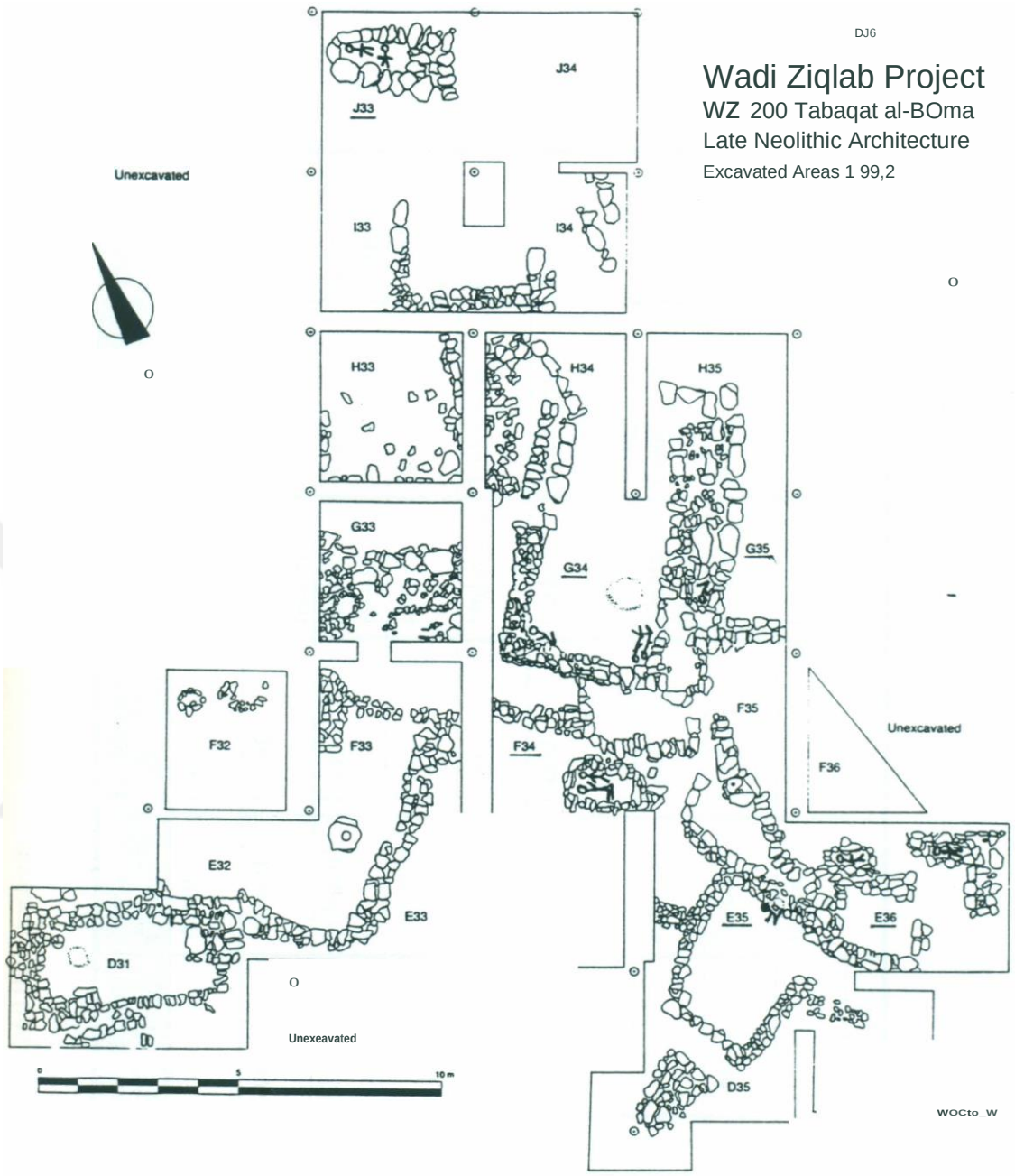


FIGURE 4: Plan view of WZ200 showing the location of each grave within the site architectural structure (Banning *et al.* 1994: 153).

TABLE -1- Summary of the nine graves and their contents.

Grave Name	Excavation Year	Grave Type	Number of Individuals	Age Group	Preservation	Burial Position	Burial Goods	Dating
133.005	1987	Cist	Two	Adults	Poor	Possibly Extended	Pottery Bowls	7800 bp
G34.022	1990	Surface	One	Juvenile	Good	Semi-flexed	None	6300-6500 bp
G35a.018	1992	Surface	Two	Subadults	Poor	Semi-flexed	None	6300-6500 bp
G35b.033	1992	Cist	One	Juvenile	Poor	Flexed	None	6300-6500 bp
G35c	1992	Unknown	Possibly One	Adult	Good	Unknown	Unknown	6300-6500 bp
F34.026	1992	Cist	Two	Subadult & Infant	Good	Flexed Extended	With Infant Dentalium beads	Possibly 7800 bp
E35.022	1990	Storage Bin	One	Juvenile	Good	Tightly Flexed	None	6300-6500 bp
E36a.026	1990	Cist	One	Juvenile	Medium	Extended	None	6300-6500 bp
E36b.016	1990	Cist	One	Infant	Poor	Possibly Extended	None	6300-6500 bp
Total 9			Total 12					

stone bowl or mortar, two pottery bowls, two pottery jars, a basalt grinding slab, and a small pierced stone disc" (Banning *et aI.1989:50)* (Figure -5-). Grave 133 was dated using bone collagen from bone within the grave and provided a date of 7800 ± 70 bp, which is equivalent to 6800-6450 cal BeE (Banning 1995). 133 is the earliest Neolithic feature at the site (Banning, pers. comrn. 1996).

Grave G34: is a surface burial excavated in the 1990 season, containing the remains of one fairly well-preserved juvenile, locus 022. As a surface grave, there were no structural boundaries for G34 and the human remains were placed on soil deposits and covered with soil. The only boundary for the grave is the north-west wall-comer of a room in area G34. The remains were placed beside the wall and, in some areas, touching edges of the room wall (Plate -1-). There might have been a shallow pit dug in preparation for G34, however it was difficult to detect during excavation (Banning *et al. 1990).*

G34's skeletal remains were in a flexed and an extended burial position. The juvenile's upper extremities were placed in an extended position: the arms beside the left and right sides of the body, with the right arm was tightly extended along the right side, and the left arm slightly flexed at the elbow beside the left side. The head was placed on the right side and raised at an angle with the face directed towards south-west. The lower extremities were in a flexed position on the right side with the knees touching the wall structure, (Plate -2-). There was no trace of cultural material with the skeletal remains of this individual .

Grave G35a: was a surface grave excavated in the 1992 season which consist of the skeletal remains of two subadults, locus 018. The skeletal remains were poorly preserved and so heavily fragmented that the chemical consolidant, Paraloid 72, was used to help in lifting them. Much similar to the grave structure of G34, G35a was a surface burial with its only boundary being the south-east comer of the same room structure that extended from area G34 to G35 as can be seen in Plate (-3-), site field photograph. The remains were placed close to the room's comer-wall structure and along its east wall. The skeletal remains were placed on soil deposits without evidence of a pit cut for the burial and covered with flat rocks and soil fill (Banning *et al.* In press).

As a double burial, the remains were buried in close approximation to each other and, subsequently, they became slightly mixed. The two subadults, A and B, were buried in a semi-flexed position beside one another and commingled lower limbs. It is speculated that individual A was first placed in the grave since its remains were beside the east wall. Subadult A was placed on the right side of its body with both arms under the cranium -that is- facing south-east. Individual B was placed on the right side of its body in a semi-flexed position with both arms around the pelvic area. The head was placed facing the east wall (Plate -3-). There were no grave goods placed with grave G35a (Banning *et al.* In press).

Grave G35b: is a cist grave excavated in the 1992 season of a poorly preserved juvenile, locus 003. The east edges of G35b were delineated by a wall that belonged to an earlier phase of occupation at the site. The original wall was rebuilt and prepared as

the east edge of the cist, with the remaining edges being constructed around the grave and covered by capstones, (Plate -1-). The juvenile was placed on soil deposits with the remains of burnt animal bones beneath the cranium. indicating that the burial ground predated the wall and the grave. The fragmented remains indicated placement on the right side in a flexed position, with the head placed on the south-west side of the grave (Plate -4-). There was no traces of cultural material buried with the remains (Banning *et ai.* In press).

Grave F34: is a large cist grave excavated during the 1992 season with good preservation of the skeletal remains of two individuals, locus 026. The remains of an infant and a subadult are almost complete. Looting that occurred at the site during the excavation resulted in the loss of some bones of the upper extremities of both individuals. F34 is very similar to grave 133 in terms of its large size and structure. F34 was cut into earlier soil deposits of the site with cist edges built from several courses of large limestone slabs that where placed within and against the surrounding soil. The four edges of the cist were used as base to place the huge cover capstones that closed the cist. The remains were not covered with soil after burial; however, the very fine soil found covering the remains was the result of soil percolating between the small openings in the capstones during the several thousand year period of burial (Banning *et al.* In press). Plate -5- is a *in situ* photograph of the cist grave during the excavation process.

The two individuals placed on soil deposits had different burial positions. The infant was placed extended in a supine position with the left hand placed on the stomach area, while the right arm extended beside the right side (Plate -6-). The subadult was placed

on the left side of this body in a flexed position, with the face facing north-east in the direction of the infant. The arms were tightly flexed at the elbow with both hands just inferior to the cranium. The feet were tightly flexed with the right foot above the left (Plate -7-). Cultural material was found on the right rib cage of the infant in the form of several dentalium beads. There were also some lithic blades located around the infant remains. However, the subadult did not have any form of cultural material associated with it (Banning *et al.* In press). According to the stratigraphy of the site, it is assumed that grave F34 dates to 7800 ± 70 bp, which is equivalent to 6800-6450 cal BeE, similar to the date of 133. This date can be verified in the near future when collagen is used in dating of the cist grave F34 (Banning, pers. comm. 1996).

Grave E35: this is a storage bin burial excavated in the 1990 with well-preserved skeletal remains of one juvenile, locus 022. This burial was the only one of its kind found at the site where a storage bin was converted into a burial place. The storage bin was a clay-lined structure that was build inside the north-east wall of a room in area E35 (Plate -8-). The storage bin was large enough to be used as an interment area for juvenile E35 who was placed over soil deposits and covered with a number of rocks. The juvenile was buried in a tightly flexed position on the left side of the body. The cranium was pushed down towards the chest area, a consequence of fitting the remains into a small area. Both arms were flexed and placed in front of the cranium with the left arm raised higher to the north than the right. The two legs were heavily flexed which caused the feet to almost touch the pelvic area (Plates -9&10-). There were no grave goods placed within the interment (Banning *et al. 1990).*

Grave E36a: is a cist grave excavated in 1990 containing medium preserved skeletal remains of a juvenile, locus 026. The cist grave was constructed of medium to large limestone slabs surrounding the four edges and covered with capstones. The infant was placed on soil deposits and not covered with soil; the soil later infiltrated through the capstones and covered the infant remains. The infant had no grave goods associated with it, and was buried in an extended supine position, the cranium directed to the north-west side with both arms beside the body (Plate -11-) (Banning *et at. 1990).*

Grave E36b: is a cist grave excavated in 1990, that revealed the poorly preserved skeletal remains of an infant, locus 016. The grave was constructed from an abandoned stone silo, that was reused as the burial place. The infant remains were placed extended and covered with only the capstones of the grave (Banning *et at. 1990).*

The eight graves were not contemporary with one another and their chronological sequence can be put in two phases. Phase one is dated (by grave 133) as 7800 ± 70bp. It is speculated that grave F34, according to its archaeological stratigraphy, has a similar date to that of 133, thus making 133 and F34 the two earliest phases in the sequence of the eight burials. Until dating of F34 is established, this assumption will stand. Phase two contains the remaining six graves, but none of them have been dated absolutely. They are, however, presumed to be later than 7800 ± 70bp and dated to between 6300 to 6500 bp (Banning, pers. comm. 1996).

2.3 **Skeletal Preservation:**

Human remains in archaeological context have different degrees of preservation, which may vary between graves in the same cemetery and between skeletal elements of the same grave. These variations are controlled by intrinsic and extrinsic factors dominant in the surrounding environment of the grave. Intrinsic factors are defined through the biological nature of the skeletal system; chemistry, size, shape, density of the bone, in addition to age of the interments, are all elements that interact together in the preservation of human remains (Henderson 1987).

The chemical breakdown of the organic structure of bone occurs naturally after death. The weakening of bonds between the protein-mineral components cause bone to be susceptible to intrinsic and extrinsic forces that cause deterioration of human remains. This leads to infiltration of minerals, bacteria and fungi into the micro structure of bone, producing internal destruction of the bone. Size, shape and density are three elements that give bone its structural features; for example, the skull is large and easily fragments under the pressure of soil due to the amount of empty space inside the cranium; whereas, the small hand and foot bones survive well (if archaeological recovery is adequate) due to their small size and regular shape. Age also contributes to skeletal preservation; the very fragile nature of young infant remains, or osteoporosis in the weak bones from old individuals, can speed up the of disintegration of human remains (Henderson 1987).

Soil type and water are two intemals forces causing different degrees of bone preservation. The nature of soil type, if acidic, may lead to bone dissolution. **In** the case of WZ200 soil type it was high in calcite concentration which helped preservation of the bones. Water is a destructive force which should be considered for any poor burial preservation; the leaching of water into graves and subsequent immersion of bone in water (depending on the drainage of the grave) leads to rapid disintegration of the skeleton (Henderson 1987).

Human and animal activity, combined with compression forces, are some of the external forces. It is people (in antiquity) who determine the kind of burial, where to bury and who was buried. For instance, a grave can be dug deep into the ground with a surrounding supporting structure placed in a primary burial soon after death, covered with soil or rocks, or in a closed grave to avoid human or animal activity. All of these can result in good skeletal preservation (Henderson 1987).

The state of preservation of WZ200's eleven individuals varied between good and poor. Grave type was a determining factor in the preservation of the remains within them The best preserved remains were those buried in the surface and the storage bin graves, illustrating that the cist graves were a poor enclosed structure that led to bone destruction. Good preservation was a term applied to the best preserved remains relative to all the interments. Thus, 'good' here describes the skeletal remains that had 80% or more of the bones present with little fragmentation. 'Poor' was a term applied to remains where 80% or less of the bones had not been recovered (for whatever reason) and there was heavy fragmentation of the remaining bones.

The best preserved skeletal remains were in G34, a surface grave, F34, a cist grave, and E35, a storage bin grave. The preservation of the skeletal remains for the four individuals in the three graves were good and the skeletons were relatively complete with moderate bone fragmentation. However, none of the four skeletons was complete, and at least 20% to 30% of the bones were missing from each skeleton. There was no particular type of bone element missing from the remains, such as the small hand or foot bones. Each skeleton was missing a certain number of bones, differing from the others. The poorly preserved skeletal remains were in 133, a cist grave, G35a & b, surface and cist graves, and E36b, a cist grave. The remains of six individuals were poorly represented by a small fraction of the number of expected bones which were, at the same time, very fragmentary. Figures -6 to 14- are diagrammatic inventories showing the state of preservation for each of the nine individuals. The skeletal remains of 133 will not be presented in this analysis due to lack of access.

Grave type and natural environmental factors were two components that influenced the state of preservation of the eleven interments. The structure of the cist graves had the form of a container with a cover; this proved to be destructive to the enclosed skeletal remains. During the winter seasons, rain water would leach down into the grave structure, settling in and around the skeletal remains until the grave dried out. The continuation of this water activity over the years within the graves contributed toward bone disintegration. The effects of water activity was reflected in the bone structure and appearance; it became brittle and fractured immediately once handled during the

process of excavation and transportation from the site. This activity can be observed in the skeletal remains from the cist graves, 133, G35a, and E36a. **In** cases where water destroyed the bones, only traces of thin white powder was what remained of the bones, such as grave G35a. An exception to this rule was in cist grave F34 that had good skeletal preservation contributed by the deepens of the grave, which in-turn prevented heavy quantities of water from settling in the grave. On the other hand, in surface and storage bin graves, there were no containing boundaries to collect rain water within the grave, and thus it flowed down along the sloping surfaces of the terrace site causing little damage to the bones, as in the case of G34 and E35, which have good skeletal preservation.

Contributing to the variable degrees of preservation was the possible human activity during the Neolithic occupation of the site, which added to bone fragmentation. For example, grave G35a was a surface burial which, contrary to the statement above, had poor preservation of the two individuals contained in. The main cause of poor preservation was the number of rocks which covered the remains, placed there by the Neolithic inhabitants of the site. The weight of rocks in the overlying soil became a compressing force that, with time, compacted the underlying bones. The result was seen on the long bone shafts which lost their original rounded contour and were replaced by a rectangular shape. Other bones such as the scapula, *os coxa* and the cranium were compressed and completely fragmented into large numbers of tiny bone fragments. Similarly, grave E35 whose remains were fragmented as a result of the pile of rocks that covered this juvenile. The rocks reached the top of the bin, which weighed heavily on the underlying skeletal remains (Plate -12-).

The heavy fragmentation of some skeletal remains, such as the two subadults in grave G35a, precipitated treatment with the chemical consolidant, Paraloid B72. The consolidant was useful in stopping further fragmentation of the bones as they were excavated and removed. The poor bone preservation caused them to immediately fracture once removed, breaking into large numbers of small fragments.

The nature of the soil at the site is characterised by being high in the mineral calcite. During the winter, the calcite crystals incorporated themselves in the coating that encrusts almost all the archaeological material on the site, including pottery, flints, human and non-human skeletal remains. This calcite coating covers all the bone surfaces of the eleven skeletal remains (Plate -13-). The strength and bonding of the calcite coating on the bone surfaces was determined by where the highest concentration of calcite crystals occurred on site (pers. obs. Shafiq)

The calcite encrustation on the bones was both advantageous and disadvantageous in the macroscopic analysis of the remains. The positive bonding of the calcite to the bones caused them to stick together as one bone, thus maintaining the articulated original burial position (Plates -13-). On the other hand, this bonding was very destructive to the bones, as is the case with grave G35a, where several pieces of long bone shaft were 'cemented' to the overlying rocks, and the only method used to recover them was to remove them by force. The encrustation affected the detailed macroscopic analysis of bone surfaces by preventing the detection of possible pathological conditions such as periosteal reaction. The encrustation also hindered the

visible appearance of some anatomical features such as the sutures of subadult F34.026's cranium, where the edges of the frontal suture were difficult to see.

CHAPTER THREE: 3.0 METHODS

3.0 METHODS

3.1 Cleaning Methods:

Five cleaning methods were used to clear the skeletal remains of WZ 200 from the calcite encrustation. The methods used: distilled water, an ultrasonic cleaner, acetic acid, hydrochloric acid, and a dental ultrasonic scaler. The results showed that the cleaning methods used destroyed the outer surfaces of the bones during the calcite removal process. Being a destructive and time consuming process, cleaning of all the skeletal remains proved to be an unproductive process. Therefore, none of the skeletal remains were cleaned and only the enamel surfaces of the teeth were cleaned with the ultrasonic scaler to assist in the study of the individuals' dental health.

In 1991, the four methods: distilled water, ultrasonic cleaner, acetic acid, and hydrochloric acid were used to clean small unidentifiable bone pieces from the juvenile in grave G34. The following is a discussion of the results of each method: distilled water was fIrst used as a non-destructive method so as not to leave any chemical traces on the bones. Bone pieces were immersed in water for a variable amount of time, such as from 5 minutes to 24 hours, in order to test the strength of the calcite and to estimate how much time was needed to break down the encrustation. However, the results showed that water had no effect on the removal of the calcite encrustation and

b)

was only useful in removing the soil from inside the bones. As a second method, the bone fragment was placed in distilled water in the ultrasonic cleaner for more then 15 minutes. The method was unsatisfactory and the calcite needed to be dislodged with the assistance of a wooden tool which damaged the outer surface of the bone.

Use of acetic acid was unsuccessful. The bone fragment was immersed in 100% concentrated solution for various periods of time, but the calcite encrustation still adhered to the bone surface. Hydrochloric acid (HCL) which was very effective and removed the calcite coating immediately in a few seconds, with a concentration of 50% to 50% water-acid solution. HCL was only used in 1991 to clean the teeth of the juvenile in grave G34. Thus, it was an effective method for cleaning the teeth of all the calcite, however the result was the loss of the enamel shine from all the treated teeth.

The most effective and least destructive method used was the dental ultrasonic scaler that was used for cleaning only the dental remains. Access to the scaler was provided by the University of Leeds School of Dentistry at the Dental Hospital in Leeds. The teeth were cleaned at the Leeds Dental Institute in the Centre for Oral Health Sciences. The concentrated sound waves were transmitted from the pointed edge of the scaler, with the steady automatic supply of water, were effective in removing the calcite encrustation surrounding the teeth. Photographs were taken before and after the cleaning process as can be seen in Plates (-14 & 15-). The mandibles of the two subadults in grave G35a were not cleaned due to the fragile nature of the bone, if they would have come in contact with water they would have disintegrated. The only disadvantage of this method was some flaking to the weak edges of teeth, usually at

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the neck areas, when the scaler was concentrated for a period of time in one spot. The purpose of cleaning the teeth was to assist in the analysis of the individuals' health through the clear observation of enamel hypoplastic lines; such was not possible unless the teeth were cleaned.

3.2 **Excavation Technique:**

Contrary to the general trend, the skeletal remains of infants and juveniles, due to their small and fragile nature, tend not to survive in the archaeological record. An additional problem is the often unqualified excavator in the field who excavates and records the remains. Untrained excavators are likely to miss some of the infant and juvenile small hand and foot bones and epiphyses, thus causing loss of some portion of the skeletal remains (Saunders 1992).

The above mentioned conditions were avoided when the skeletal remains of WZ200 were excavated in 1992. It was important to ensure that no information was lost when excavating the human burials and that all the bones were recovered from each interment. In order to accommodate the limited size of the site and the small number of graves, an excavation technique was designed to help record and document every aspect of each grave. The aim of this method was to accurately document the exact location of each bone in the burial *in situ,* since once the remains were removed, without proper documentation, the information is lost and cannot be retrieved. This method was implemented by drawing the skeletal remains on graph paper at a scale of 1: 10, with continuous recording of the stratigraphic levels that the remains lay in. With

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the aid of the field drawing, each bone was given a number and packed individually with the number written on the outside of the packing material (tissue paper in paper bags) (Shafiq 1995). This method was used to document only the graves discovered during 1992 season, G35a, G35b, and F34. Before the 1992 season this method had not been devised.

The result of this methodology was an accurate documentation of all the bones in each grave, which ensured no mixing of the remains, especially in the double burials. The method was a great asset in the identification of infant bones such as those in grave F34 which, by knowing the location of each bone, helped to ensure that no other infant was present. The other benefit was assisting in determining the exact burial position of individuals, such as the orientation of the head and the location of each hand, if under the head or over the pelvic area. Thus, this method assisted in the recovery of all the bones of each individual including the small hand bones and the epiphyses.

In the previous two seasons, 1987 and 1990, this method had yet not been devised, and therefore the recording was different. The bones of each individual were packed together unnumbered as a group and not singly; this caused unnecessary bone mixing and contributed to further fragmentation that affected and lengthened the identification process for each bone. One unfortunate result of the method employed in 1987 is that in grave 133, a double burial, the location of each bone was not documented. No attempt was made to trace and separate the bones of each individual, and the bones were packaged as one and not two individuals. To further complicate the matter, the skeletal remains of these two individuals are being held in the possession of the 1987

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field osteologist who, in turn has not returned them to the director of the project. The lack of two individuals from the total sample will affect the final results of this analysis. Some questions would not be possible to answer whether the two individuals were subadults or adults, and if any of the two had pathological conditions that would contribute to the picture of health of this population in the Neolithic period.

3.3 **Macroscopic Methods:**

The skeletal remains of the nine individuals were macroscopically analysed in terms of determination of sex, estimation of age-at -death, and health status.

3.3.1 Determination of Sex

Sexual dimorphism begins during the foetal stage and continues until adulthood where the differences between the two sexes become defined. Around eighteen years and above, the characteristics used in sex estimation are well-marked and sex can be determined with accuracy. The fundamental difference between males and females lies in body proportions. The skeleton of an adult male, on average, is larger and more robust than of a female, and in the latter the pelvis is designed for childbirth and displays specific features that reflect this function (Ubelaker 1989a). There are three features of adult skeletal remains that are used to determine sex; these are: the skull, pelvis and metrical data (Roberts 1996).

Contrary to adults, determination of sex for juveniles and subadults is not a straight forward matter. The main reason affecting accurate determination is the different rates of developmental growth between children of the same age group, plus the fact that females have different growth rates than males (Saunders 1992). The features used to determine sex in juveniles and subadults are not manifested and developed in the skeletal system to give a reliable sex estimate (Roberts & Manchester 1995, Roberts 1996). Therefore, determination of sex for the nine juveniles and subadult from WZ200 were not attempted, since there are no clear methods developed to give an accurate sex determination (Saunders 1992).

3.3.2 Estimation of Age-at-Death

Due to the nature of WZ200 sample, being composed of infants, juveniles and subadults, the sample dictates more emphasis on the methods applied to the estimation of age at death for subadults and infants. WZ200 sample constituted eleven individuals whose age range is between infancy to around adulthood.

Estimation of age-at-death is an important part of skeletal analysis, since age can give information about the age categories represented in the study sample, and at what age death occurred, a feature of the health of the population (Roberts & Manchester 1995). Estimating age at death from skeletal material is undertaken using two procedures: measuring the degree of skeletal and dental growth that the body had reached at the time of death and correlating this age with studies done on populations of known age to get an approximation of the true chronological age (Ubelaker 1989a).

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Thus, there are two age estimations given to each skeleton under study, a biological age and a chronological age (Johnston & Zimmer 1989). Age for subadults can be estimated by measuring the growth rates of the (1) dentition, including formation, calcification and eruption, (2) diaphyseal length of the long bones, and (3) appearance and union of the epiphyses (Ubelaker 1989a).

When estimating age for adults other methods have to be used since by the age of 20 to 25 most of the growth of the skeleton has been completed. The methods used for subadult ageing can no longer be used for adults. Adult age can be estimated through the use of several methods, if bone preservation permits, and all should be used to ensure a more accurate estimate. The methods mentioned here are put in a sequence from the most reliable method (the first three) to the least. The latter methods are recommended for use when the more reliable methods are not applicable due to poor bone preservation. These methods are: pubic symphyseal surface, pelvic auricular surface of the ilium, sternal extremity of rib ends, cranial suture closure, and dental wear. It is difficult to give an accurate age estimate for an adult skeleton and, therefore, an extended age range is usually the best a researcher can give, e.g. up to 40 to 50 years of age at death with a maximum of 75 years (Roberts 1996, Ubelaker 1989a).

Subadult age can be estimated with confidence, since the body passes through several progressive stages of maturation that is biologically timed. These stages are restricted in their range, and thus age estimation is more accurate when compared with the slow and unrestricted degenerative changes that the adult goes through (Roberts 1996). The

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most reliable ageing methods for subadults is dental development; the basis of dental ageing is the evaluation of the developmental stage that the teeth have reached at the time of the individual's death. This assessment is done visually and with the aid of radiography, since a radiograph gives an insight into the calcification process of the crowns and roots in the alveolar processes before eruption; thus it is becoming an essential tool in age estimation (El-Nofely & Iscan 1989). There are several ageing techniques that were developed from different populations of known ages which are implemented in this study.

Several factors affect the rate of dental development that should be considered whenever confronted with age estimation of a particular population. The interaction between internal and external factors affecting dental development is the key behind different rates of growth. Genetics, sex, and hormones, combined with nutritional, social, environment factors and geographical location, all influence the rate of dental development, and any method used for age estimation should be evaluated according to the population under study for comparative suitability (El-Nofely & Iscan 1989).

WZ200 was a late Neolithic population that lived in Jordan around the ages of 6700 - 6300 bp. There is no comparative study for Neolithic populations from the Near East which can be used in this analysis. The tables published by El-Nofely & Iscan (1989:241- 245) for the emergence of deciduous and permanent teeth of boys and girls from different ancestry groups one of the closest studies that can be used for age estimation of the WZ200 subadult (N=9) individuals, even though tooth emergence is not as accurate as tooth formation. In their tables the authors indicate that the Negroid

population has the earliest tooth eruption, followed by Caucasoid, with the Mongoloid (Asian) being the last.

WZ200 population is not considered Caucasoid, and it was treated as an intermediate between the Negroid and the Mongoloid for two reasons. Firstly, because of the geographical location of the Near East being in an intermediate area between the Asian in the East and the Negroid in the west; and secondly, the presence of the Asian genetic shovel-shaped trait ofthe lateral maxillary incisors (Brothwell 1992: 115) of the two subadults F34.026 and G35a.OI8A. The tables collected from Egyptian data reported by El-Nofely & Iscan (1989:241-245) were used, being the closest to WZ200 material since it is closer geographically to the Near East than any other populations studied. Two age estimates (as a girl and as a boy) were taken for each individual from WZ200 since sex can not be determined for juveniles and subadults with any accuracy. The maxillary and mandibular ages of each sex were averaged to give one dental age.

The aforementioned tables are supported by two studies. The first study was developed from the analysis of a Native American population that demonstrate the various stages of deciduous and permanent tooth formation and eruption (Ubelaker 1989a: 71). This table is one of the reliable methods of age estimation, as the variation between males and females are combined into one chart. The second study by Moorrees *et al.* (1963a and 1963b), analysed modern white children. The study was concerned with the formation stages of mandibulary teeth for both the deciduous and permanent teeth in each stage of crown and root resorption and formation (Moorrees *et al.* 1963a, 1963b). The same method was followed here; two age ranges (for a girl

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and a boy) were recorded using mandibular teeth for each individual of the nine from WZ200. The two tables produced by Smith (1991:163) for permanent mandibular teeth of males and females were used in the ageing of the WZ200 sample, since the tables provide a simpler calculated version of the Moorrees *et al.* method.

The diaphyseal length of long bones was the second method used to estimate age for the WZ200 skeletal remains. This method is not as reliable as dental development and is affected by internal and external factors. The growth rate of the long bones has a wide range of variation between children of the same age group and between populations. Therefore, diaphyseal length of long bones should not be used as the only ageing criteria, but as a supporting method to dental development (Ubelaker 1989a). In addition, diaphyseal length, when correlated with dental age, can be used as an indicator for variations in bone size and growth rates of the population under study (Saunders 1992). Published in Ubelaker (1989a:70-71) are the Arikara data that is composed of mostly Native American populations which have been developed for age estimation of archaeological groups, in which the diaphyseal length of long bones are correlated with dental development using the Moorrees *et al.* method (Ubelaker 1989a).

The last method for age estimation of the nine individuals of WZ200 deals with the appearance and union of the epiphyses or secondary ossification centres. The human body at birth has 450 ossification centres and by adulthood most of these centres will disappear or unite to other bones to give rise to the adult number of bones of 206. The process of appearance and union of the epiphyses occurs in all parts of the human

skeleton and is distinguished by its timed sequences that for a healthy nourished population is a reliable age indicator (Krogman & Iscan 1986). The use of this method as the only age indicator is recommended when dental development and the diaphyseal length of long bones are difficult to determine; otherwise, this method was used with the WZ200 sample to support the previous two methods (Ubelaker 1989a).

In archaeological excavations, the recovered remains of subadults represent an unhealthy segment of the population that did not live into adulthood, thus making them a biased sample (Saunders 1992). It is logical to consider that the process of bone growth should be the same in all populations; however, an element of variability occurs between populations and between males and females where the latter matures on average two years faster than males. Combined with this variability, and the effects of nutrition, diseases and environmental influences, the timing sequence for the appearance and union of the epiphyses are all affected (Krogman & Iscan 1986). Disease and malnutrition can easily slow down the rates of growth and epiphyseal appearance and fusion, and thus a gap will result between the biological and the chronological age. For example, a malnourished child, according to bone growth, may be aged around eight years old, but the true age may be at least older by two years as a result of stress related factors (Johnston & Zimmer 1989).

Epiphyseal appearance and fusion is most useful for ageing individuals between the ages of ten to twenty years old. Three stages have been established for this method as mentioned by Ubelaker (1989a:75) 1) epiphyses and shaft separated 2) epiphyses and shaft fused with their fusion line still visible, and 3) complete fusion with disappearance

of the line. The timing between beginning and complete fusion is a process that takes several years (Ubelaker 1989a, 1989b), thus an estimation of age through epiphyseal fusion is recommended to have five-year intervals (Buikstra & Ubelaker 1994), with a plus or minus one year (Krogman & Iscan 1986). The last epiphyses to fuse is the medial end of the clavicle, fusing between the ages of twenty-three to thirty years, and thus growth ends on average at twenty-eight years old (White & Folkens 1991).

The assessment of degeneration of the sternal extremity of the rib ends is believed by some to be one of the more reliable ageing methods for adult remains (Ubelaker 1989a). This method is applicable to the analysis ofWZ200 subadult remains, since the first three phases are used to give ages for subadults. Male rib sternal age phases are: phase 0 (16 and younger), and phases I (17-19). The female rib phases: phase 0 (13 and younger); phase I (14-15); and phase II (16-19). The basis of this method is by observing the age-related changes that occurred at the costochondral junction of the rib, usually the fourth rib. Two tables were devised to compensate for male and female differences, since the latter mature earlier (Iscan & Loth 1986). The disadvantage of this method is that when dealing with archaeological remains, the preservation and the identification of the fourth rib is difficult. Therefore, the sternal ends of ribs 2-7 (Loth & Iscan 1989: 118) or the sternal ends of ribs 2-9 (Dudar 1993 :797) can be used with the same ageing criteria used for rib four. In addition, the degeneration of the sternal rib ends is also affected by the sex and ancestry of the individual and, therefore, the appropriate controls for sex and ancestry should be used (Dudar 1993, Loth & Iscan 1989).

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When estimating age, several criteria should be employed to give all the possible information about the biological age which is then used to estimated age-at-death (Krogman & Iscan 1986). Biological age is affected by the majority of the influences that the body goes through during childhood until maturation. Sexual dimorphism, variability between individuals of the same age, variation between different geographic variants, combined with influences of diseases, malnutrition, and environmental forces may all affect the age estimated. The age of the WZ200 sample of subadults was estimated by correlating dental development and diaphyseal bone length with epiphyseal fusion. The results of these correlations provide an insight into the health and growth rates of the late Neolithic population of WZ200 in Jordan.

3.3.3 Dental Health

Teeth, as part of the human skeletal system, are exposed to the external and internal influences that affected the human body during life. The results of environmental influences occurring during childhood and through the period of dental development may be seen as a permanent record (Lukacs 1989). The amount of information retrieved from a full study of individual teeth is diverse and can give evidence on diet, dental diseases, stress-related influences and socio-cultural behaviour. The outcome of such integrated analysis may give an insight into a past populations' way of life (Roberts & Manchester 1995). Dental diseases and anomalies are divided into several categories, specific recording methods were used in the analysis of WZ200 nine individuals' dental health. The accuracy in the methods used for the recording of size

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and location of caries will be a determining factor in the use of the data in the final analysis of the WZ200 sample.

The dental health of WZ200 nine individuals were assessed for the following categories of diseases: (1) infectious - dental caries, dental abscess, periodontal disease; (2) degenerative - calculus accumulation; (3) developmental - enamel hypoplasia; (4) genetic - anomalies (Lukacs 1989); and (5) cultural and environmental influences- dental attrition. Dental caries are the outcome of infectious bacterial activity concentrated on a certain area of the tooth that leads to demineralisation of the enamel, and later to destruction of enamel and dentine and formation of cavities in the teeth. The fermentation of the sugar component in food by bacteria in plaque is the main cause of this infectious disease (Lukacs 1989). Caries are distinguished by their smooth and rounded edges, in contrast with the irregular and jagged edges of post-mortem damage. A small carious lesion can be identified through the use of a sharp probe indicating a small cavity space (Schultz 1988a). The method designed by Schultz (1988a:494) deals with description of caries size from the very small to the largest. The following grades were used in the WZ200 analysis: grade I: pin-head sized; grade II: sesame seed sized; grade III: pepper-com sized; grade IV: rice-grain sized; grade V: half the crown destroyed; grade VI: completely destroyed. (Grades V and VI are only used for the molars.)

A dental abscess may develop as a result of heavy attrition and/or a large dental caries which exposes the pulp cavity, in addition to periodontal disease which makes way for bacterial deposition and infection of the tooth. The infection then spreads to the

surrounding periapical tissue followed by the formation of pus. The formed pus eventually causes strain in the alveolar process, giving way to the formation of a drainage sinus to help relieve the pus pressure. Abscesses are diagnosed visually by their location at the root areas of the tooth, and distinguished from post-mortem damage by the smooth rounded edges of the sinus; otherwise, if the drainage sinuses are not present, then abscesses are diagnosed by radiography (Lukacs 1989, Roberts & Manchester 1995). The recording method described by Lukacs (1989:271) and Schultz (1988a:493) are the two accurate methods in use since the size of the sinus is recorded by measuring the sinus diameter in the alveolar process, and in the latter by seed size by comparing the sinus size to the gradual seed size from small to large.

Dental calculus and periodontal disease are two diseases that are connected in which the former is a leading cause for the latter. Calculus is the result of mineralisation of the mineral crystals deposited within dental plaque. There are two types of calculus: supragingival (more common) and subgingival (Hillson 1986) with both types located often around the buccal and lingual sides of crowns. As calculus irritates the gums this causes inflammation (Lukacs 1989), leading to the formation of a periodontal pocket, the main feature of developing periodontal disease. After the formation of a pocket, recession of the alveolar bone follows resulting in the loss of the tooth and later remodelling of the tooth socket (Hillson 1986).

In archaeological bone two process of periodontal disease are distinguished: inflammatory and non-inflammatory. The difference between the two is in the reaction of the alveolar bone to the disease process. Inflammatory periodontitis is characterised

by its aggressive irregular recession of the alveolar bone. The edges of the alveolar rim are not rounded but have the appearance of channel-like features and irregular porous structures. Advanced stages of inflammatory periodontitis are seen in the formation of new bone deposited as point-like features on the edges of the alveolar rim. With inflammatory periodontitis only, periodontal pockets are associated and all the features that characterise it are not diagnostic to non-inflammatory periodontal. The alveolar bone in non-inflammatory periodontal has smooth features with a slightly wavy look. In recording calculus and periodontal diseases table (-2.4-) shows the five grades used: grade I: slight; grade II: moderate; grade II: high; grade IV: intense; and grade V: severe (Schultz 1988a).

Dental enamel hypoplasia is the result of stress disturbance that occurred during the growth of teeth. The effects of this disturbance were recorded as pits or grooves on the tooth enamel on either of the four sides. Enamel hypoplasia may be seen on several teeth at the same location on the enamel surface, which some researches use as an indicator of the timing of the stress. Malnutrition and/or any serious child illness are some of the causes for the stress episode. Therefore, by measuring the exact location of the hypoplastic defect an age prediction for the defect can be made (Hillson 1986). Schultz (1988a:494) gives five grades to scoring enamel hypoplasia: grade 0: normal; grade I: very weak (a normal variant); grade II: weak; grade III: moderate; grade IV: high; grade V: severe (Table -2.3-).

Dental attrition is not a disease process, but the result of normal wear on the occlusal surfaces during the mastication process. The different rates of wear depend on the type

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of diet, if coarse or tender, and on cultural behaviour if the teeth were used as a form of a tool (Roberts & Manchester 1995). Two methods were used for scoring the amount of wear on the teeth of the WZ200 sample. For the incisors, canines, and premolars Perizonius & Pot (1981:379) was used, and Brothwell (1992:72) for the molars.

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DENTITION

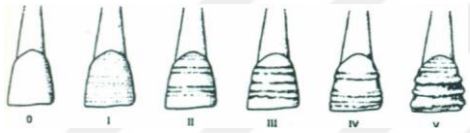
TABLE -2- Methods applied in analysis ofWZ200 dentition.

1- Bite(Brothwell 1992:52)

Overbite
Underbit
e
Edge to edge bite

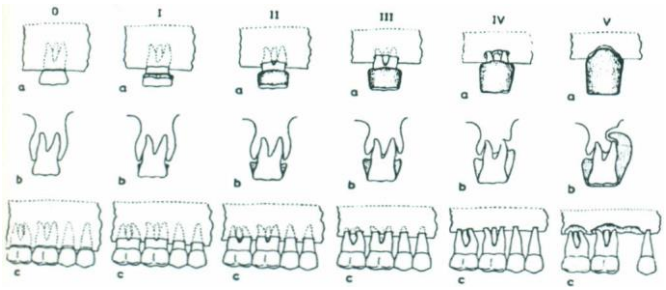
2- Abrasion:Chart of (Perizonius 1981 :379) for the scoring of wear degrees for the incisors, canines and premolars; (Brothwell 1992:72) chart of the molars.

3- Enamel Hypoplasia:(Schultz 1988:494)



Grade 0: Normal; Grade I: Very weak (a normal variant); Grade IT: Weak; Grade ill: Moderate; Grade VI: High; Grade V: Severe.

4- Calculus and Periodontal Disease:(Schultz 1988:493)



Stages of calculus and alveolar atrophy. The left side Grade 0: Normal; Grade I: Slight; Grade IT: Moderate; Grade ill: High; Grade IV: Intense; and Grade V: Severe.
z) Upper row: Stages of calculus formation on maxillary molars.
aa)Middle row: Same stages of (a) but in anterior view; the left side is the lingual and the right side is the buccal.
c) Development stages of alveolar atrophy of right maxillary posterior teeth. Stages I-IV demonstrate the developmental stages of inflammatory and non-inflammatory, while stage V occurs only in severe calculus. The molars in stage V were held by roots and the soft tissue. 44

bb))

The combination of the three rows shows the connection between alveolar atrophy and calculus formation.

6- Caries:(Schultz 1988:494)
Grade I: pin-head sized; Grade II: sesame-seed sized; Grade III: pepper-com sized; Grade VI: rice-grain sized; Grade V: half of crown destroyed; Grade VI: complete destruction of grown. Grades V-VI for use with molars.

7- Abscess: (1) (Schultz 1988:493)
Grade I: sesame-seed sized; Grade II: pepper-com sized; Grade III: pea sized; Grade IV: bean sized; Grade V: Cherry sized.
(2) Lukacs 1989:271).

Abscess Type:
Internal drain
External drain

dd)

3.4 Microscopic Methods:

The use of microscopy in the study of archaeological skeletal remains has been limited in past decades, with most of the work concentrated on soft tissue analysis (Garland 1987). Histology, as a technique, is widely used in the diagnosis of pathological conditions in modem clinical circumstances. The combination of both disciplines, pathology and histology, gives rise to the science of palaeohistology. This field of study is concerned with the microscopic analysis of archaeological bone and teeth through the use of histological sections. There are several uses for palaeohistology, some of which are listed here: (1) to help understand the process of bone decomposition on a microscopic level (Garland 1993); (2) in addition to macroscopic analysis, assisting in the diagnosis of pathological conditions in archaeological bones; (3) to differentiate between antemortem and postmortem changes; and (4) to give more accurate age estimation to archaeological (Garland 1989) and forensic cases (Garland 1985).

Knowledge of bone histology is important when analysing archaeological bone. Mature bone is formed of two types of bone, dense or compact (cortical) bone, and spongy or trabecular (cancellous) bone. The cortical bone is positioned external to the internal cancellous bone (William & Warwick 1980), and both have the same histological structure. The microstructure of mature bone (lamellar bone) has regular organised collagen fibres; on the other hand, immature bone (woven bone) has irregular distribution of the collagen fibres (Garland 1989).

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The histological structure of cortical bone takes the following basic arrangement (Plate -16-). The lamellar fibres are arranged in concentric layers around an osteon, called the Haversian canal, and a cement line marking the boundaries between each Haversian system. Within the lamellar structure are small cavities called lacunae which, during life, contain an osteocyte (a bone maintenance cell), but in dry bone the lacunae are empty (Garland 1989). Connecting the lacunae are small canals called canaliculi that transmit nutrients to the osteocytes (White & Folkens 1991). Interstitial lamellae are found between the Haversian systems, which are composed of old lamellar bone. Enclosing all the Haversian systems are internal and external circumferential lamellae. When viewing a histological section of cortical bone using polarized light, the Haversian systems will show the 'Maltese cross' of the lamellae structure as birefringence. By using higher magnification, the 'Nomarsky Phase' is observed as a three dimensional representation of the section (Garland 1989).

There are three basic methods for the preparation of archaeological bone for histological examination. (1) Decalcification and paraffm wax embedding, the most widely used method in laboratory work. The bone sample is placed in decalcifying solution to remove all traces of minerals and then washed and put in paraffm wax. The use of this method with dry bone gives unclear histological sections. (2) Double embedding of undecalcified bone in paraffm wax, where archaeological samples are undecalcified and placed in paraffin wax, and left to cool before any sectioning of the hard bone. (3) Resin embedding of undecalcified bone; this is suitable for dry bone, since undecalcified samples are immersed in resin that have similar hardness to the bone (Garland 1989, Schultz and Drommer 1983).

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Supported by the histological laboratory at the Department of Anatomy, the University of Gottingen, Germany, and the supervision of Dr. Dr. Michael Schultz, eleven histological samples were taken from WZ200 skeletal material; Table 3 is a list of the eleven samples. The sections were taken from the diaphyseal shafts of long bones, where they were hand-sawn as to avoid further fragmentation of the bones if cut by electrical saw.

TABLE -3- Details of the eleven histological sections.

Section. Number	Grave Number	Individual Age Group	Type of Section	Size of Section
1	F34.026	Subadult	Left Tibia Diaphysis	Maxi = 21.9mm Mini = 12.2 mm
2	F34.026	Subadult	Right Tibia Diaphysis	Maxi = 19.8mm Mini = 20.6mm
3	F34.026	Subadult	Right fibula Diaphysis	Maxi = 16.5mm Mini =9.2mm
4	F34.026	SubaduIt	Left Femur Diaphysis	Maxi = 23.7mrn Mini = 15.0mm
5	F34.026	Infant	Right Femur Diaphysis	Maxi = 17.5mm Mini = 13.3mm
6	G35a.018.1	SubadultA	Right Femur Diaphysis	Maxi = 28.7mm Mini = 15.0mm
7	G35a.OI8.2	Subadult B	Right Femur Diaphysis	Size = 19.2 mm
8	G35b.003	Juvenile	Left Femur Diaphysis	Maxi = 20.0mm Mini = 16.8mm
9	G35b.003	Juvenile	Right Tibia Diaphysis	Maxi = 17.5mm Mini = 14.1mm
10	E35.022	Juvenile	Left Humerus Diaphysis	Size = 11.1mm
11	G34.022	Juvenile	Left Femur Diaphysis	Size = 11.5mm

gg)

When archaeological skeletal remains are recovered they often do not have good preservation, thus the methods of histological embedding using paraffin wax and celloidin, are not suitable to give the best histological results. The histological method of preparation devised and used in Gottingen, consisted of the embedding of undecalcified bone samples in epoxy resin (Biodur E12) for a period of four weeks until the resin infiltrated and solidified the bone (Schultz and Drommer 1983). This method is a modification of a technique devised by Hagens (cited in Schultz 1988b) where Biodur E12 was used in the plasticization of macroscopic sections, and was thus modified for its use in archaeological thin sections. The use of Biodur E12 has the following advantages: (1) high permeability (2) good dispersion, (3) extreme low viscosity, (4) an uncomplicated processing technique, (5) when used with microradiographs, gives clear results, and (6) has the ability to process sections with large surfaces (Schultz 1988b).

The process of embedding of undecalcified histological section using Biodur E 12 takes the following sequence. After sectioning, the bones are immersed for one to two days in methylene chloride (dichloromethane), which is an intermediate medium to prepare the sections for embedding. The epoxy resin Biodur E12 is then mixed with its corresponding hardener E1, in the ratio of 100:28. The bone is then immersed with the embedding mixture in a container, with a minimum thickness of the resin layer at not less than Smm, The container is then placed in controlled vacuum setting to allow the remaining methylene chloride to bubble and rise up in a steady stream to the surface. Thus, by controlling the vacuum, the sample will not rupture as a consequence of the bubbling action. After the bubbling stops, the vacuum setting is changed progressively

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until reaching 5 Torr, a process that takes 4 to 8 hours. The last step is to shut off the vacuum and leave the sections within the container to harden at room temperature; this lasts from two to four weeks (Schultz 1988b).

Once solidification has occurred, the section is then prepared for sectioning and placed on glass plates for microscopic analysis. A method devised by Schultz and Brandt and Schultz and Drommer, (cited in Schultz 1988b) both used for the preparation of thin sections with relatively large surfaces of the size 75x46mm. The thin section is recommended to have a thickness of 50-70<7m, and is cut by a machine type (270109) designed by the Dr. Steeg and Reuter company in Frankfurt, Germany. After cutting, the thin section is placed on a glass plate using Biodur E12, hand ground and polished using soft sand-paper (Schultz 1988b). The remaining original samples from WZ200 are being kept at the laboratory in Gottingen for further additional sectioning when needed in the future.

The skeletal remains of WZ200 were sectioned for histological analysis for two purposes, the diagnosis of pathological lesions on a microscopic level and the study of the diagenetic process in the bone microstructure. Bone is a hard crystalline substance that is composed of collagen and protein fibres. During life, bone reacts to surrounding influences that the body goes through, such as adaptation to the environment in terms of nutrition, disease and physical activity. These forces influence and leave their marks on the skeleton's microscopic and macroscopic structures. The study of such changes, when compared to normal bone structure, helps in the diagnosis of lesions, and

jj)
inferring the state of bone decomposition from an archaeological context (Martin 1991).

The reaction of bone to stress can lead to an abnormal appearance of the macro- and microstructure of the bone. Two kinds of cells respond to stress: osteoblasts, bone forming cells, and osteoc1asts, bone resorption cells. The two kind of cells react in three distinct ways when a disease process is present in the body, bone formation, bone destroyed, and both occur (Garland 1988a). The diagnosis of the disease process is undertaken with the aid of two methods: at the macroscopic level, based on the degree of response of the bone cells, the grade of severity, and the distribution pattern in the body are all considered. Supplemented with microscopic analysis, through the use of histological sections that can detect the disease process at a microscopic level (Martin 1991).

Histological investigation of archaeological bone has revealed that the bone micro-structure is preserved and intact enough to allow pathological investigation of the samples (Stout and Teitelbaum 1976). The advantage of histology in the diagnosis of pathological lesions comes with its ability to observe the response of osteoblasts and osteoc1asts to the disease process, when no macroscopic changes are observable (Martin 1991), since the disease process is still in early stages (Schultz 1993). Some disease processes tend to have a distinct structures, so that diagnosis of the lesion can be done through the use of histological sections (Schultz 1994).

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Histological investigations are a great asset in the analysis of bone decomposition on a microscopic level. The interaction between bone and the surrounding biological and chemical factors of the burial environment, is a process termed taphonomy (Garland 1993, 1987). The macroscopic observation of bone preservation is viewed separately from microscopic changes during the decomposition process. The macroscopic changes are visible and deal with the forces of bone destruction such as compression forces from the weight of rocks causing fracture and damage to the bones (Garland 1988b).

Histological analysis of bone decomposition has several classifications that are found in archaeological bone, according to studies by Garland (1987, 1988a, 1989). First, destructive changes that have two forms: (1) generalised destruction, is the disintegration of the osteonal structure, but visible lamellar bone is still present around the Haversian canals; this kind of destruction usually occurs in the outer areas of the cortical bone. (2) Focal destruction, is the opposite, in which here the loss of bone structure is seen to be focal. This has been described by Hackett (1981) as 'tunnelling' which has four forms of focal destruction: centrifugal wedl, linear longitudinal, budded, and lamellate. Second, inclusions are the result of mineral and biological (fungi and bacteria) inclusions into the Haversian canals, osteocyte lacunae and the canaliculi. Third, is the infiltration of material such as mineral into the bone matrix and replacing it.

Thus with the knowledge of the above-mentioned classification of bone destruction, the distinction between decomposing and pathological features in bone histological

ll)
studies can be ascertained (Garland 1987). When analysing WZ200 histological sections, attention was given to the microscopic differentiation of the processes between pathological lesions and diagenesis (taphonomy).

CHAPTER FOUR: 4.0 RESULTS

4.0 RESULTS

4.1 Results of Macroscopic analysis:

4.1.1 Age Estimation:

Several methods were employed to estimate age for the eleven individuals from WZ200. Special emphasis was given to choosing the age methods, in order that the most appropriate methods were used for this late Neolithic population from the Near East. It is hoped that these methods may compensate for the time difference between the techniques developed from modem day populations used to age prehistoric populations, since there are no appropriate Neolithic populations being used as the data set for age estimation methods. The results of each age estimate for each individual were put into 'an age estimation table' (Tables -4 to 12-), then all the estimated ages from the ten methods used were averaged to give two age estimates, for a boy and a girl. The results of age-at-death estimations of the WZ200 eleven individuals are divided into four age groups: (1) two adults, (2) three subadults, (3) four juveniles, and (4) two infants; and put into table 13, which is a summary of all the estimated ages for each of the eleven individuals.

TABLE -13- Summary of the estimated ages for the twelve individuals.

Individual Number	*Estimated Age*
133.005	Age estimated from tarsal bones as two adults.
G34.022	An average age for both a girl and a boy: between 5 to 6 years old.
G35a.018A	An average age for both a girl and a boy: between 12 to 13 with a maximum of 15 years old.
G35a.018B	An average age for both a girl and a boy: between 13 to 14 with a maximum of 15 years old.
G35b.003	An average age for both a girl and a boy: between 8 to 10 years old.
G35c	Adult age group, no other remains to give an age range.
F34.026 Subadult	An average age as a girl: between 14 to 16 with maximum of 18 years old; and as a boy: between 16 to 18 with a maximum of 19 years old.
F34.026 Infant	An average age for both a girl and a boy: between 0.7 to 0.9 months, with a maximum of 1 year and 5 months.
E35.022	An average age for both a girl and a boy: between 11 to 12 years old.
E36a.026	An average age for both a girl and a boy: between 5 to 6 with maximum of 7 years old.
E36b.016	The average size indicate around prenatal age.

4.1.2 Estimation of living stature:

Estimation of living stature was not assessed since there is no method of doing so for subadults. Three points that are interconnected and affect stature estimation for subadults, these are:(1) variability in growth rates between individuals of the same age group, (2) sex and age are two parts that have direct effect of stature, in which males and females have different growth rates associated with age, and (3) the effects of the individual health and the nutritional level (Roberts 1996). Since sex is not known for

the WZ200 eleven individuals this will hinder their stature estimation as there are differences between males and females, the former being taller then the latter (Brothwell 1992).

Stature estimation, when calculated, is considered an indicator of stress during growth. Stature is affected by individual's health and growth will fluctuate as health changes from poor to good. Malnutrition, disease, environmental stress, and genetic composition all have effect on stature. Environmental stress came with the transition to agriculture which caused a decline in stature in some groups in the past (Roberts 1995). As this is a Neolithic population it would be advantageous to know whether there were any effects on stature with the advent of agriculture in the Near East as WZ200 is a farming community who were harvesting plants on a large scale (Banning 1995). A further point is genetic composition, as WZ200 is a small, and fragmented sample, and as a data set it is of a limited value in its contribution to information concerning stature variation of Neolithic populations in the Near East, particularly in Jordan.

4.1.3 Dental Health:

The results of the macroscopic analysis of the dental health of the nine individuals indicate the presence of three dental categories: the pathological condition of abscesses, the degenerative process of calculus, and the developmental condition of enamel hypoplasia. Dental caries and periodontal disease are two lesions that had no traces within the dentition of WZ200 individuals. The dentition of each individual of

the nine is described in details with the use of a dental chart, tables (-14 to 20-). The two adults in grave 133 were excluded from the this part of the analysis since the only bones present were four tarsal bones.

Dental attrition seemed to be minimal when considering that diet in agricultural periods was coarse (Lukacs 1992). This minimal amount of dental attrition is clearly visible on the occlusal surfaces of the two subadults A&B in grave G35a.018, where attrition was almost not perceptible on the premolars and molars (Plate -17-). There was also a minimal amount of attrition on the deciduous molars of the four juveniles. The only individual with moderate dental wear was the subadult in grave F34.026 (Plate -18-) were the premolars and molars show grades from two to four of dental attrition (Perizonius & Pot 1981). The occlusal surfaces of the central maxillary incisors of the subadults, F34.026 (Plate -19-) and G35a.018 A&B (Plate -20-), all have a similar antemortem feature, which was a single groove with smooth and polished edges located on the occlusal surfaces of their central incisors.

Enamel hypoplasia was found to be the most common on the buccal and lingual surfaces of almost all the teeth in each of the nine individuals. The hypoplasia had the form of grooves that varied in depth and had a sequence of re-occurring episodes of stress as observed on the lingual and buccal sides of the canines of both subadults A&B in grave G35a.018 (Plate -21-); there was a sequence of six deep grooves of grade IV (Schultz 1988a) for the subadult A, and five grooves for the subadult B with grades of III and IV.

Calculus was the second most common pathological lesion after enamel hypoplasia. Calculus was visible on only the three subadult teeth, F34.026 had the highest grade between the three individuals, as grade I (Schultz 1988a) (Plate -15-). The two subadults in grave G35a.018 had traces of calculus mostly around their posterior teeth. The last pathological condition, abscesses, were found only in the mandibulary teeth of the subadult F34.026. An area of translucency, located under the root of the right canine, extending antero-inferiorly to the lateral and medial right incisors (Plate -22-). The translucency could be a possible abscess showing destruction of bone, however, there was no caries or periodontal disease which often underlay an abscess (Roberts & Manchester 1995). Another two small areas of translucency located inferiorly and around the roots of the right third molar (Plate -23-) could be the beginning of an internal abscess.

There were some variations than the normal observed in the mandibles of some of the individuals that are worth noting, that could be termed genetic anomalies. First, a difference in the shape and size of the mandible from the lingual side was seen in the two individuals, F34.026 and G34.022. The former seemed to have a rather narrow and almost a V shaped mandible (Plate -24-), while the latter followed the normal internal curvature (Plate -25-). For comparison reasons, G34.022 was compared to a British juvenile of similar age from Blackfriars cemetery #203. The results showed that the width of G34.022 mandible was thicker than the counterpart from antero-posteriorly side (Plate -26-), and especially at the anterior side (Plate -27-). Second, congenital absence of the second premolar was found in the right mandible of juvenile E35.022 (Plate -28-), where the second deciduous molar was retained showing signs

of root resorption. Third, the presence of the Asian genetic trait of shovel-shaping on the lateral maxillary incisors in the two subadults, F34.026 (Plate -29-) and G35a.018A. This genetic trait was accompanied by another trait where the left lateral maxillary incisors of the same individuals had rotation of the aforementioned tooth to the mesio-lingual side. This rotation brought the tooth closer to the distal side of the left central incisor (Plate -30-). Fourth, the genetic trait of Carabelli cusp (Brothwell 1992) was found on both side of the permanent maxillary first molars in the dentition of juvenile G34.022 (Plate -31-).

4.1.4 Pathological Conditions:

Several pathological conditions were found in the skeletal remains of the rune individuals. Two features were found in several of the iridividuals 1- porosity of the endosteal surfaces of the long bones, accompanied by 2- thickening of the cortical bone along the diaphysis of the long bones. In addition, two individuals were found to have some evidence of Vitamin D deficiency (Rickets). British archaeological skeletal materials from three British cemeteries: Blackfriars (Boylston et al 1991), Chichester (Lee 1988) and Holton Le Clay (Chundun 1992) were used for comparison with radiographs of the WZ200 skeletal remains. This allowed comparison of the cortical thickness of the long bones, to see the degree of abnormality, while considering at the same time, the difference that existed between these two populations.

The diaphyses of the long bones, especially the tibiae and right fibula, show the most porosity, with thickening of the endosteal surfaces. This case is very clearly

demonstrated in the skeletal remains of the subadult, F34.026 (Plate -32-). The left tibial endosteal surface had heavy porosity extending along the diaphysis, with a concentration in the mid-third portion of the shaft. The porosity was accompanied by thickening of the cortical bone, being heaviest at the mid-third portion of the diaphysis. The two conditions, porosity and the thickening, affected the normal contour of the bone, causing the shaft to expand in size and became rounded; and thus the landmarks of the tibia such as the pronounced edges of the interosseus crest were lost. The left tibia was radiographed with a British individual from the cemetery of Blackfriars subadult #89 (Plate -33-) of a similar age and the large difference in size between the two is noticeable at mid-section (Plates -34 & 35-). Same kind of changes can be observed in the right tibia (Plate -36-) where endosteal porosity with thickening of the cortical bone concentrated at the mid-third portion of shaft is seen. The shaft has enlarged in size as the result of porosity and thickening (Plate -37-). The right tibia's shaft has a little coating of the calcite encrustation on the outer cortical surface, which in-turn revealed periosteal reaction in the form of striations (Plate -38-).

The same condition was found in the right fibula and the left femur of subadult F34.026. The left and right endosteal areas of the right fibula's cortical bone had extensive porosity that extended along the diaphysis. The cortical bone was not thickened as in the case of the two tibiae; on the contrary, the cortical bone became thinner due to the extensive porosity that had taken a large part of the inner surface of the diaphysis (Plate -39-). The porosity had expanded and enlarged the diaphysis when compared to the Blackfriars subadult #89 (Plate -40-). The porosity had also changed the normal contour of the fibula, which was replaced by a rounded contour where

anatomical features such as the interosseus crest could not be recognised (Plate -41-). The left femoral diaphysis had slight porosity (when compared to the tibiae) of the endosteal surface with slight thickening of the cortical bone at the mid-third of the shaft (Plate -42-). Such tibial thickening is the result of new bone formation and accompanied by loss of the contour of the tibial shafts is a character of treponemal disease, possibly bejel that usually affects the lower limbs, the tibiae in particular (Hershkovitz *et al.* 1994a).

Endosteal porosity and thickening of the diaphysis were evident in the upper limb long bones of infant F34.026, but not as high as subadult F34.026. The shafts of both humeri for infant F34.026, had slight cortical thickening when compared to the infant from the British cemetery of Holton LeClay Church #B42 (Plate -43-). The right humerus, had porosity of the endosteal side of the shaft in the form of one circular line (Plate -44-). The left ulnar shaft had porosity of its endosteal side, which contributed to the thickening of the cortex. The right ulna shaft had porosity of the endosteal side, with a heavy concentration at the mid-third and proximal end. The porosity was accompanied by thickening of the cortical bone, observed along the shaft and concentrated at the mid-third and proximal end (Plate -45-). Lastly, both radii had porosity of their endosteal sides which contributed to the cortical thickness of their shafts and a concentration of thickening at the middle and proximal part of the shafts (Plate -46-).

Cortical thickness and porosity can be seen in juvenile E35.022 in the left tibial diaphysis (Plate -47-), and along the diaphysis of the left ulna (Plate -48-) but only

slightly, when compared to the two individuals in grave F34. The endosteal porosity was not limited to the upper limb and lower limb bones, but was located along the shafts of some hand phalanges of subadult F34.026 (Plate -49-). The endosteal porosity can be seen along the shaft of the right fifth metatarsal (of either subadult G35a.018A or B) as one circular line (Plate -50-). The endosteal porosity found in the upper and lower limbs of the aforementioned individuals could have been caused by several disorders, including Vitamin C and D deficiencies and anemia (Schultz, pers.comm. 1996, Roberts & Manchester 1995, Tayles 1996).

The remaining individuals have cortical thickness, but it is not considered pathological since there were no signs of any bone added or resorbed. It is assumed that this cortical thickness is just a variation on the norm for this population. Yet it is difficult to state what is normal variation for a late Neolithic population when there are no other populations from the same period with which to compare the results of this analysis. The following are a list of these 'normal' individuals: (1) juvenile G34.022: the right tibial diaphysis (Plate -51-); the right radial diaphysis (Plate -52-); (2) juvenile E35.022: the left humeral diaphysis (Plate -53-) and right humeral diaphysis (Plate -54-); the right and left radii (Plate -55-) diaphyses; and the right ulna diaphysis (Plate -56-); (3) juvenile G35b.OO3: the right fibula diaphysis (Plate -57-).

Changes which may be consistent with Vitamin D deficiency (rickets) were found on the fibulae and tibia of juvenile E35.022 and subadult F34.026. The outcome of vitamin D deficiency causes softness in the weight-bearing long bones, which bend as a result of walking (Roberts & Manchester 1995). The juvenile E35.022 right fibula had

medial-lateral bending along the shaft with bone thickening at the medial side. The left fibula had bending with bone thickening along the medial side of the shaft, but not as high as the right side. The left tibia had slight medial-lateral bending at the proximal-third part, accompanied by bone thickening on the medial side (Plates -58 & 59-). Subadult F34.026 had medial-lateral bending of the right fibula (Plate -60-), but the cortical thickness that usually accompanies Rickets was not clear on the Plate (-61-).

There are several pathological conditions and some structural variations found within the skeletal remains of subadult F34.026 that do not have any similarity with the other individuals from WZ200. First, the frontal and parietals have expansion of the diploe towards the outer and inner tables. The diploe expansion was concentrated mostly at the medial-central area of the cranium, while laterally it becomes less (Plates -62&63-). Second, the right parietal's meningeal grooves, in particular the grooves posterior to the orbit, were deeper than those of the left side (Plate -64-). Third, a structural variation found in the right cerebral surface of the greater wing of the sphenoid has a rather thick edge which exceeds the normal range when compared with the cerebral surface of juvenile E35.022 (plate -65-). Fourth, is the size proportion ofthe frontal vs. parietal, which the former was larger than the latter. The frontal chord measured 130.0mm, while the parietal chord was 94.0mm. Last, the frontal crest seemed to be of normal size, when compared to the high and sharp frontal crest of juvenile E35.022 that might be an abnormal variation of the WZ200 small population (Plate -66-).

Juvenile E35.022 had several perforations on the ectocranial surface of the frontal and parietal bones, three have penetrated to the endocranial side, and two are present in the

form of depressions on the ectocranial surface. On the postero-lateral side of the coronal suture a square-shaped perforation with a step-like structure leading to the perforation is visible (Plate -67-). The measurement of the outer sides of the perforation are: antero-posterior = 12.3mm and medio-lateral = 13.3mm; the exact size ofthe perforation without the step-structure is antero-posterior = 12.3mm and medio-lateral = 0.89mm. The appearance of the perforation suggest post-mortem damage. Little can be postulated as to whether the perforation was antemortem or postmortem since there was no sign of any healing process, even though there were some sharp regular incision marks around the edges of the perforation. The heavy encrustation that covered all the bone surface deterred any further statements about the exact nature of the perforation, i.e. whether it was the result of trephination or not. The other penetrating perforation has a similar structure to the aforementioned one. There were two depressions on the ectocranial surface, one on the left posterior parietal and the other located on a parietal fragment of either side (Plate -68-); the latter depression seemed to have antemortem appearance (Plate -69-).

There are several features found in the remains of some of the individuals that will be summarised here. F34.026 had several non-metric traits: the flexure of superior sagittal sulcus is bifurcate, divided hypoglossal canal, and vastus notch of the right patella (Buikstra & Ubelaker 1994). The juvenile G34.022 has possible evidence of squatting facets on the dorsal side of the head of both tali (Plate -70-). Part of a right temporal bone of an adult was found in area G35c, adding the total number of WZ200 to twelve. The presence of two distal and intermediate hand phalanges found in grave F34 (Plate -71-), and one distal hand phalanx recovered from grave E36a, might indicate

the possibility of another two individuals of foetus age. With these findings, it is possible that the total number of WZ200 inhabitance was fourteen, if the four hand phalanges could be considered as representation of two fetuses.

4.2 Results of Microscopic analysis:

Microscopic analysis of the eleven histological sections taken from seven individuals as indicated in table 3, was conducted by Dr. Dr. Michael Schultz at the University of Gottingen (August 1996) and later discussed with the researcher of this dissertation for interpretations. The analysis revealed: (1) the presence of the treponemal condition possibly bejel, in the skeletal remains of subadult F34.026, and (2) revealed the state of micro-preservation where the bone reached fossilisation state.

Subadult F34.026 was diagnosed to have treponemal disease, possibly bejel. This diagnosis was based on the histological examination of four thin sections from the left femur, both tibiae, and the right fibula. The four sections had two distinct features associated with treponemal conditions that are detected only through histological sections and usually found in long bones, these are: 'polster' which is (reactive bone), and 'grenzstreifen' which is (original cortical surface) (Schultz 1994, August 1996). 'Polster' (reactive bone), is seen mostly in tibial shafts where due to the active inflammatory process of the disease, causes periosteal reaction in the form of newly built bone. This new bone has an internal structure that consist of curved, compact, dense and parallel layers of lamellar structure; these are called 'polster'. 'Polsters' (reactive bone), are sometimes separated from one another by crypt-like resorption

caps that are the result of "hypertrophic blood vessels of the affected periosteum". 'Grenzstreifen' (original cortical surface), is defined as the boundary line between the newly formed periosteal layer of bones and the original cortical bone (Schultz 1994).

The histological sections from subadult F34.026 left tibia, and left femur all show the characteristic features of treponemal disease, possibly bejel. The left tibia has 'polster' (reactive bone) in the middle between two cracks (filled with minerals), and 'grenzstreifen' (original cortical surface) can be clearly seen horizontally in the middle of the 'polster'(reactive bone) (Plates -72&73-). (Plate -73-) exhibits the resorption caps that are usually accompany 'polster' (reactive bone) formation. The left femur exhibits newly built bone formation (not polster) with resorption caps; however, the newly built bone is separated from the original primary cortical bone by the 'grenzstreifen' (original cortical surface) (Plate -74-). Last, the right fibula section exhibits newly built bone formation but does not have the polster character, the new bone could be the result of an inflammatory disease (Plate -75-). The remaining histological sections taken from the other six individuals did not reveal any characteristic features of the treponemal disease, but rather exhibited only the degree of bone decomposition (Schultz, August 1996).

The histological sections gave insight into the degree of microscopic preservation of the WZ200 skeletal sample. There is generalised destruction within the microscopic structure of the sections demonstrated by the presence of the calcite particles. The sections showed the variation in thickness of the calcite encrustation covering the bone outer surfaces, from slight (Plate -75-) to heavy (Plate -72-). The variation of the

encrustation was seen not just between the different bones samples, but within the same histological section (Plate -75-). Plates (-72&76-) demonstrates how the calcite covering the outer surface had infiltrated into the cracks located in the outer surface of the cortical bone. As well, the calcite was covering the inner edges of the cortical bone, around the medullary cavity (Plate -77-).

Generalised destruction was demonstrated in all of the eleven sections, of fossilised bone. The process of fossilisation was reached by a sequence of events that started with the burial and the subsequent body decomposition. Following decomposition, the bones were attacked by fungi and bacterial activity that destroyed most of the collagen matrix. As the result of postmortem pressure from the covering rocks and soil, the bone surfaces cracked. The open cracks in the outer surfaces of the bone led to the infiltration of minerals (most probably calcite, since it was covering the bone surfaces) into the inner structure of the bone. The mineral crystals filled all the cracks and expanded with time into the empty spaces in the bone, such as the Haversian canals, blood vessels, and empty lacunae with the end-result being bone fossilisation (Schultz, August 1996).

The results of the eleven histological sections indicated that there were no complete preservation of bone microstructure as seen when comparing plate (-16-) as a preserved bone structure with the WZ200 plate (-78-). The calcite crystals had infiltrated the Haversian canals and extended outside the canals into the lamellar structure, producing a variety of worm-like destructive areas (Plates -74&75-). Bone decomposing can be seen in plate (-78-) where black coloured areas were the result of

air filling the destroyed bone matrix. Focal destruction is characterised by the 'lamellate tunnel' feature as indicated by Hackett (1981), as seen in plate (-76-) where the 'rectangular black' tunnels were arranged in a circular structure surrounding a mineral filled Haversian canal.

CHAPTER FIVE: 5.0 DISCUSSION

5.0 DISCUSSION

5.1 Interpretations of Agricultural Manifestation on the Health of WZ200, a Late Neolithic Settlement:

The Neolithic age witnessed dependence on agriculture and animal domestication, which were practised on a large scale when compared to the previous hunter-gatherers' period. The late Neolithic period witnessed intensive agricultural activity with emphasis on harvesting certain cereals that are high in calories and storage ability, but have little nutritional value (Roosevelt 1984, Cohen 1989), and are a poor source of iron. The ability to provide large quantities of food through agriculture has resulted in an increase of population. Infectious diseases thrive and multiple within a crowed population facilitating the transmission of infections lesions. (Roberts & Manchester 1995). With agriculture came the establishment of permanent settlements and the exploitation of all available food sources and land cultivation. However, high dependence on agriculture put the late Neolithic populations at risk of famine and malnutrition as the result of crop failures (Cohen 1989).

WZ200 settlement was part of minimum of six late Neolithic settlement and farmsteads that occupied the Wadi Ziqlab region. These were settlements scattered in the region and situated at a close distance to springs and stream sources. Unlike the previous Pre-

pottery Neolithic densely populated villages, the late Neolithic people in the Levant were divided into several farmsteads and settlements. This division helped to reduce competition for food and water resources for the inhabitants and their animals, which grazed in the surrounding hills. WZ200 was a small settlement where farming and animal domestication were fully practised, as indicated by the large numbers of 'sickle blades' and faunal remains. The settlement had several rooms built of strong structured stone walls and the remains of storage plant jars (Banning *et al. 1994).*

Population size generally played a role as a determining the standard of health (Roberts & Manchester 1995). There are two factors to be considered when dealing with the health status of WZ200 population: number of inhabitants, and the settlement location within the Wadi Ziqlab region. Based on the excavation small scale, WZ200 was a small settlement that could not have been heavily populated, and thus competition for food sources between its inhabitance might have been very limited. However, competition for scares food sources might been caused by the other settlements located in the same Wadi Ziqlab region, especially at times of failed crops (for what ever reason, like droughts), causing malnutrition. The location of the WZ200 settlement did not place it in isolation. It was likely in contact with the closest settlements and farmsteads, since all had to share the water sources. This kind of mixing would facilitate the exchange of infectious diseases through social contact.

Buried skeletal remains indicate a certain social treatment given to these particular individuals after death. There were differences in the mortuary treatment of the twelve individuals of WZ200 that could be attributed to three reasons: (1) chronological

sequence where the remains were buried at various periods during the several hundred years of site occupation, (2) abandonment of particular areas of the settlement that were no longer in use, thus storage areas became a suitable places for burial, And (3) difference in mortuary treatment for the various ages and sexes. Since sex was not determined for this subadult sample, making any interpretation of burial treatment in relevance to gender was not possible.

However, one conclusion can be stated about the inhabitants of WZ200. Infants and juveniles had a certain social statuses after death. Infant bodies were not discarded in trash deposits as in the pre-pottery Neolithic periods (Rollefson *et al.* 1992). On the contrary, each infant and juvenile were treated as equals to the older subadults in terms of grave construction, being buried in a cist grave. A second social distinction that all individuals had primary graves suggests no apparent secondary burial. Thirdly, each infant was placed in one cist grave in an extended position, while juveniles and subadults had flexed burial positions, an indicator of social differentiation between ages. It is unlikely that a full understanding of the treatment of all ages and sexes of the inhabitants of WZ200 will be understood, unless the site is completely excavated in the future.

The recovered sample of twelve individuals from WZ200 settlement is a biased sample, since it does not represent the whole population that once lived at the site (Saunders 1992). The macroscopic analysis of the remains indicated that nine of the twelve burials were those of subadults, making this sample a very limited one representing only a fraction of the WZ200 population. It would be difficult to give any information

about the whole population based on the remains of twelve individuals. The recovered sample is considered the end result of a process of elimination starting with the total number of WZ200 inhabitants once buried at the site; followed with the chances of survival from postmortem disturbance (Waldron 1994).

The recovered sample represented only a fraction of the total population. These were the individuals who suffered some kind of health disturbance that ended with their death (Waldron 1994). The mortality rates of infants and juveniles were usually high in prehistory, and certainly would be the same in late Neolithic periods (Pennington 1996). Infants and juvinles usually do not survive childhood diseases, were gastroenteritis and respiratory infections constituted most of the main causes of death (Roberts & Manchester 1995). In addition, infant mortality could be attributed to malnutrition rather than infectious diseases (Ortner 1989). Since the dead sample was a reflection of a biased section of the inhabitants of WZ200, this causes difficulties in the interpretation of frequency of pathological conditions within the sample. The dead would have a higher frequency of diseases than did the survivors who later died from different causes (Wood *et al. 1992).*

5.2 Interpretation and Differential Diagnosis of the Pathological Conditions:

The level of health determines an individual's ability to resist environmental stresses. The skeletal remains with bony lesions are indicative of the body's ability in the past to resist and adjust to a disease process for a period of time before death. The bony changes are illustrative of a constitution rather than a poor one, since the body resisted

the disease process (Goodman 1991). Nutrition has a strong impact on the health of an individual. With malnutrition, certain nutrient elements are not supplied to the body and thus lower the body's immune system, causing susceptibility to infections diseases and the development of pathological conditions within the skeleton (Ortner 1989, Roosevelt 1984). Being a sedentary population, it is assumed that WZ200 lived most of their times indoors in the stone structured rooms and within the boundaries of the settlement, thus increasing the changes of having little hygienic conditions, especially when dealing with human waste (Cohen 1989, Ortner 1989), adding to the chances of being infected with diseases (Pennington 1996).

5.2.1 Dental Health:

The human skeletal system responds to stresses in limited number of ways, as newly built or resorbed bone; and on teeth as a permanent record in the form of dental enamel hypoplasia (Goodman 1991). For enamel hypoplasia to develop, a sub adult had to overcome the stress induced on its health and resume normal dental growth (Wood *et al.* 1992). Dental heath has been reported to be affected by an agricultural subsistence economy, from several areas in the Middle East and Asia. Dental enamel hypoplasia, caries and wear all have been demonstrated to increase with the dependence on agriculture (Lukacs 1992).

Hypoplasia was found in the permanent teeth of the three subadults (F34.026 and G35.018 A&B), indicating several recorded periods of stress for these individuals. The large number of hypoplastic grooves found with the G35.018 subadults seems to

indicate a re-occurring event that stopped their growth rate several times, starting from around the age of three until around the age of seven. The habitation at WZ200 extended for several hundred years, hence it is possible that the individuals buried had different chronological sequence. However, the two subadults of 035.018 were buried together almost at the same time indicated by their burial position. Their heavy hypoplasia could be connected with episodes of malnutrition caused by crop failures that lasted for several years. If this is possible, then by dating 035 grave one could obtain evidence to suggest a period of famine. This kind of evidence could be provided thought the study of Wadi Ziqlab region's geology.

Contrary to the increase in dental hypoplasia, caries and wear are almost non-existent on the dentition of the WZ200 individuals. There were no cases of caries in any of the teeth of the nine individuals. Dental wear was very limited indicating the consumption of a tender diet that left very little dental wear on the occlusal surfaces. Cereals were softened through the use of grinding stones (Cohen 1989, Hershkovitz *et al.* 1994b), several have been found at WZ200 site. An alternative explanation to the lack of dental wear is seen with the dentition of the two subadults 035.018, were low dental wear could be associated with the lack of food substance such as cereals to consume, consequently causing malnutrition and the formation of enamel hypoplasia. A common dental feature that the three subadults had on their maxillary incisors was the mid-occlusal groove, that can be considered chipping of the tooth (Plates -19 & 20-), that could be the result of certain use for the incisors as a form of a tool.

5.2.2 Pathological Conditions:

In most archaeological material, soft tissue is not preserved to add in the accuracy of pathological diagnosis. Diagnosis of paleopathological conditions is highly dependent on the analysis of radiographs, and the distribution of bony changes in the skeletal system giving clues to a particular disease process. When skeletal remains are analysed, the researcher will observe the 'static' state of pathology in which the individual had at the time of death (Wood *et al.* 1994). Histological investigation of pathological conditions is becoming an important tool in the diagnosis of lesions. The reaction of the human body to a disease process begins at a microscopic level that can be easily detected by histological examination (Schultz 1993). Adding to the above is the experience of the researcher with knowledge of how the pathological lesions manifest themselves in the skeletal system (Miller *et al. 1996).*

The skeletal remams of subadult F34.026 exhibited a pathological condition that through histological examination of four sections was diagnosed as treponemal disease, possibility bejel (Schultz, August 1996). Treponema is an infectious disease that has four forms: pinta, yaws, endemic syphilis, and venereal syphilis. Pinta affects only skin, in contrary to the remaining three which affect the skeletal system with similar changes. Venereal syphilis is considered the most serious, affecting the nervous system and the arterial circulation, and with diagnostic skull changes. Venereal syphilis can be passed from mother to infant resulting in congenital syphilis. The strength of the immune system determines the host resistance to the infection and the speed of recovery. The

basic bony changes of the three kinds is osteomyelitis of the lower limb bones, especially the tibiae (Roberts & Manchester 1995).

Endemic syphilis and yaws usually affect the juveniles with pathological changes occurring mostly to both tibiae, while yaws produces destruction of the nasal area. The two kinds are limited in their geographical distribution, in which endemic syphilis spreads in dry warm climatic, and yaws in humid areas (Roberts & Manchester 1995). Geographically, endemic syphilis had its origin in the Mediterranean area, where it is termed 'bejel'. The word 'bejel' has probably an Arabic root, where it was used to describe a non-fatal lesion. Macroscopically, 'bejel' seen to affect mostly the tibiae bilaterally enlarging both sides. The infection can spread to the fibula and femur, but does not seem to produce any destruction to the nasal area. **In** the Negev area of Israel, skeletal remains of a Bedouin tribe were documented to have suffered from bejel, and had the following feature: the triple enlargement and thickening of the tibial shaft, with periosteal reaction in the shape of newly built bone formation, and drainage sinuses in advanced stages of the infection (Hershkovitz *et al.* 1994a).

The skeletal remains of the subadult F34.026 exhibited similar features to those described by Hershkovitz *et al.* (l994a) in Israel. First, the Wadi Ziqlab region is located north-east of the Nagev area in Israel, in which the climatic conditions in the late Neolithic were dry and warm climate providing favourable conditions for the survival of bejel. Second, histological features 'polster (reactive bone) and grenzstreifen' (original cortical surface) described by Schultz (August 1996) are clearly visible in the tibial and femur sections as the diagnostic criteria for treponemal disease

(Schultz 1994). In addition, both tibiae had the characteristic feature of bejel, the enlargement and the thickening of the diaphyseal shafts (as described in the result chapter). There was no nasal destruction so yaws is ruled out.

Differential diagnosis for the tibial enlargement and the thickening of the diaphyseal shafts suggest a possible case of severe anemia. Iron deficiency is one of the several causes of anemia. Iron is usually concentrated in red meat, however, diet that is dependent on plant remains would have low quantities of iron, as in the Neolithic. There are other causes of anemia in addition to poor diet, like parasitic infection, infectious diseases, and genetic anemia (thalassaemia). The characteristic features of anemia which usually occur during childhood, are: (1) the 'hair-on-end' feature that is the result of thinning of the cranial outer table while thickening of the inner diploe, usually seen on the frontal and parietal bones; (2) Cribra orbitalia, porosity, on the orbital roofs (Roberts & Manchester 1995). Infant and juveniles are usually affected by anemia and exhibit skeletal changes at that young age (Stuart-Macadam 1991).

Cases of anemia has been reported by Tayles (1996) for a sample dating to 4,000 years from Thailand. Anemia was reported as hypertrophy of the cortical bone at several areas in the skeletal system: the zygomatic bone, heavy porosity with extensive proliferation of the sub-periosteal surface of the shafts in long bones, and the aforementioned features in the shafts of hand phalanges and the fifth metatarsals. Tayles' results are important for their similarity to features seen with the skeletal remains of WZ200 individuals. The extensive proliferation of the sub-periosteal surface mentioned by Tayles (Plate -79-), is very similar to the F34.026 tibial sections (Plate -80-), however, in the former the proliferation is seen as a second layer with a line

separating the original cortical bone from the newly built bone. On the other hand, the proliferation of F34.026 tibial shafts is not separated but as an extension of the original cortical bone. Thus, it would be rather difficult to attribute the tibial pathology of F34.026 as a result of an anemic process, when the cranium does not have the 'hair-on-end' feature and the orbits do not show any signs of cribra orbit alia. Anemia could be attributed to the proliferation of the cortical bone in several of WZ200 individuals' long bones. For example, infant F34.026 has a similar distribution of cortical diaphyseal proliferation on the upper limbs as that reported by Tayles (1996: 16) (Plate -81-).

The juvenile in grave E35.022 exhibited bending of both fibulae (Plates -58&59-), indicating a possible vitamin D deficiency such as rickets. This kind of deficiency is caused by the lack of ultraviolet light, a situation seen in industrial countries where individuals are kept in-doors and away from sunlight for prolonged periods, resulting in vitamin D deficiency and bending of the weight-bearing lower limbs (Roberts & Manchester 1995). The case of rickets for juvenile E35.022 needs some consideration of what would had been the cause of such a pathology, since the Wadi Ziqlab region enjoyed high amount of ultraviolet light during Neolithic times (Field 1993).

CHAPTER SIX: 6.0 CONCLUSION

6.0 CONCLUSION

Conclusion:

The skeletal remains of nine individuals recovered from the late Neolithic settlement WZ200 located north-west of Jordan were the main subject of this dissertation. Macroscopic analysis, including radiography, combined with microscopic examination of eleven histological sections gave rise to several statements concerning the health of this small agriculturist population.

The differential diagnosis of the subadult, F34.026, tibial condition was proposed, first as treponemal disease, possibly 'bejel' (Schultz, August 1996). Based on the combination of two methods, macroscopic analysis (triple enlargement and proliferation of the endosteal surface causing diaphyseal thickening); and microscopic-histological analysis (the two histological treponemal characters 'polster' (reactive bone) and grenzstreifen (original cortical surface), both methods indicate a treponemal lesion. Second, as a possible case of severe anemia when the mid-section of subadult F34.026 tibiae are compared to the similar tibial proliferation reported by Tayles (1996). However, since subadult F34.026 did not show other characteristic signs of anemia like hair-on-end diploic expansion and cribra orbit alia, the second diagnosis does not stand strong. Although anemia could be considered a second pathological

lesion that might had its beginning with subadult F34.026 since there was some degree of diploe expansion with thinning of the outer cortical bone of the central frontal and parietals and in the hand phalanges, similar to the cases presented by Tayles (1996). Anemic conditions are a possible diagnosis to the proliferation of the endosteal surface found with the skeletal remains of three individuals: infant F34.026, juvenile E35.022 and either subadult in grave G35a.018, where similar changes have been described by Tayles (1996).

Populations differ in their genetic composition and their response to environmental influences (Lukacs 1992), and a disease process in the past might have had different pathological changes than the ones seen in later periods and today (Miller *et al. 1996).* The health of WZ200 inhabitants can be stated as good, even thought there were several pathological conditions found. Individuals exhibiting skeletal lesions indicate healthier lives where the body's immune system resisted and adapted to environmental stresses. To the contrary, individuals with no skeletal lesions indicate unhealthy lives, since resistance and adjustment to causes of stress were not possible (Wood *et al.* 1992). (This research is concerned only with lesions that affect the skeletal system and not the soft tissue). According to the above statement, WZ200 population had led a healthy lives where the individuals resisted possible malnutrition for several years that left its signs as enamel hypoplasia. The F34.026 treponemallesion, was a long-standing one (as showed by histological sections), thus indicating the body's ability to withstand the metabolic changes caused by this infection. However, WZ200 is a dead and biased sample, where individuals had died from certain disease processes.

The pathological lesions found within the skeletal remains of WZ200 population indicate their non-dependence on pOI?ulation density. Anemia is not an infectious disease (like tuberculosis) that requires a large host population to facilitate its transmission. Although treponematosis can be an infectious lesion, there was one treponemal condition found within WZ200 sample (until further recovery of additional skeletal material). The two conditions, anemia and treponematosis, are not indicative of a large densely populated areas. And thus coinciding with Banning (1994) statement indicating a shift in population distribution of the late Neolithic people from large villages to small settlements (like WZ200) situated along stream terraces in the Wadi Ziqlab region. This distribution resulted in reduction in population density and in-turn reduced the transmission of infectious diseases that were usually found within agriculturist settlements (Cohen 1989). It is worth noting that the incidence of pathological lesions found amoung the nine individuals of WZ200 are high for such a small sample.

Opportunity should be given for further future research in the Wadi Ziqlab region. The need to have additional skeletal remains from the same period is important in this kind of study. This will help in strengthening the results when there are other skeletal populations to with which to compare them, thus helping to provide knowledge of the normal and abnormal variation that are specific for late Neolithic populations.

Future recommendation for WZ200, is the full excavation of the site in an attempt to fmd the remaining skeletal material of the rest of the inhabitants, such as the adults. Further skeletal samples from the site are needed to see if the treponemal lesion was a

single case or that other individuals had the same lesion. Thus, comparison can be made with the other settlements and farmsteads that where located in the Wadi Ziqlab region (Banning 1994).

APPENDIX A: FIGURES



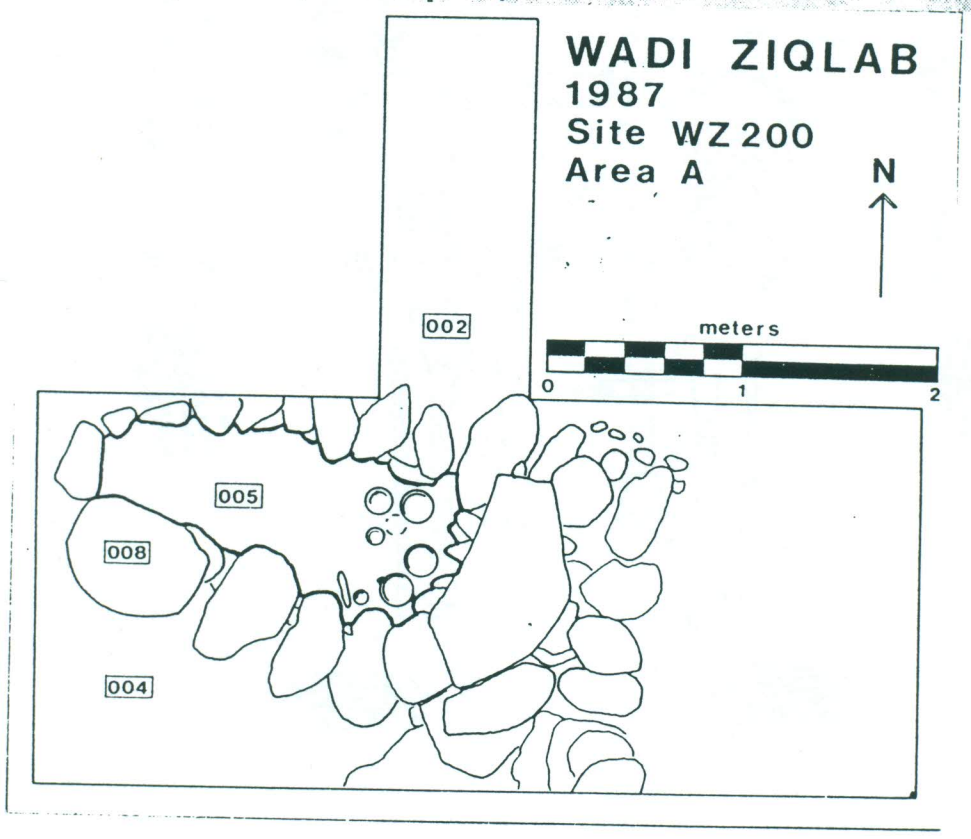


FIGURE 5: Field photograph and plan of grave J33 (Banning *et al.* 1989:370).

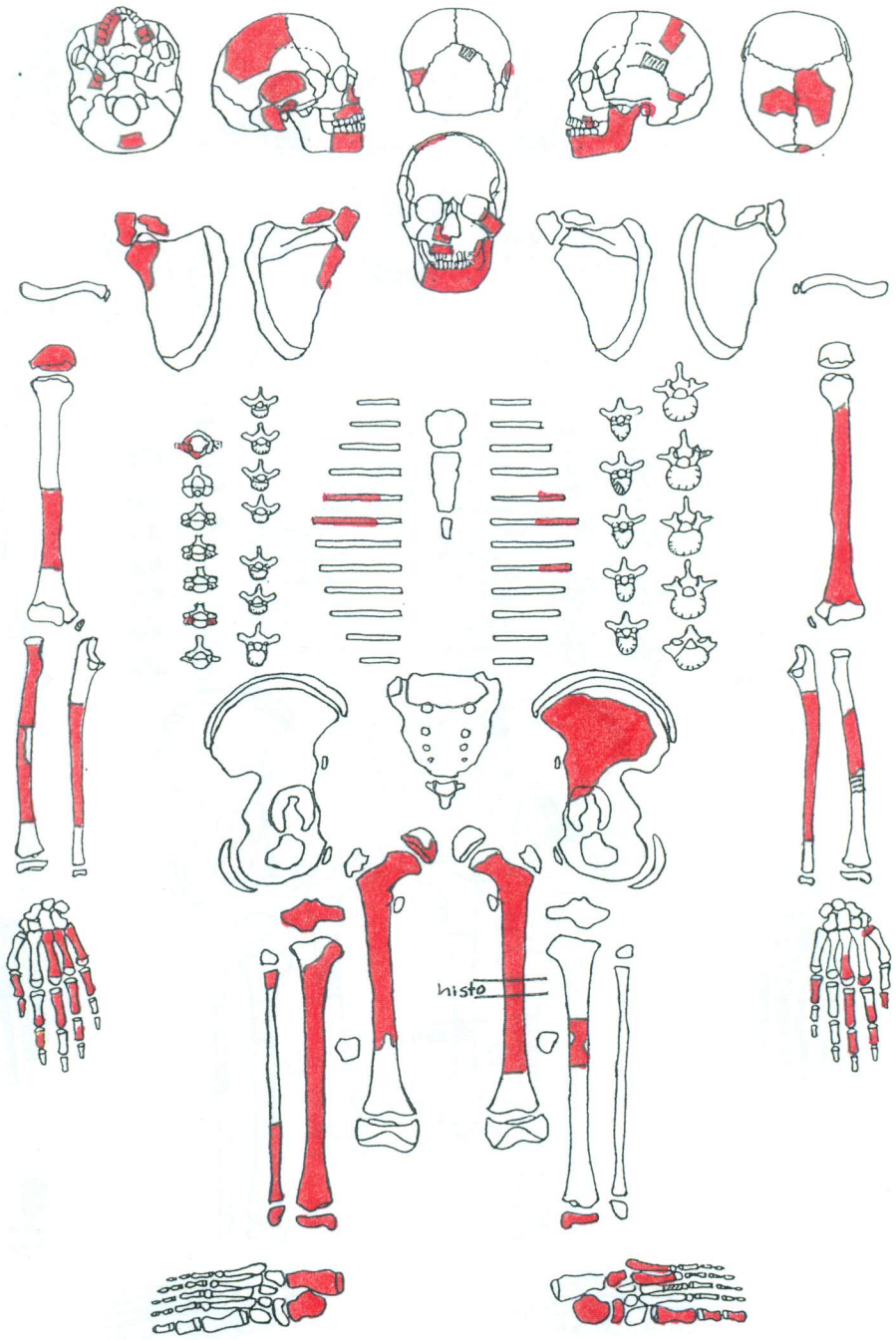


FIGURE 6: Diagrammatic inventory showing the state of preservation of juvenile G34.022

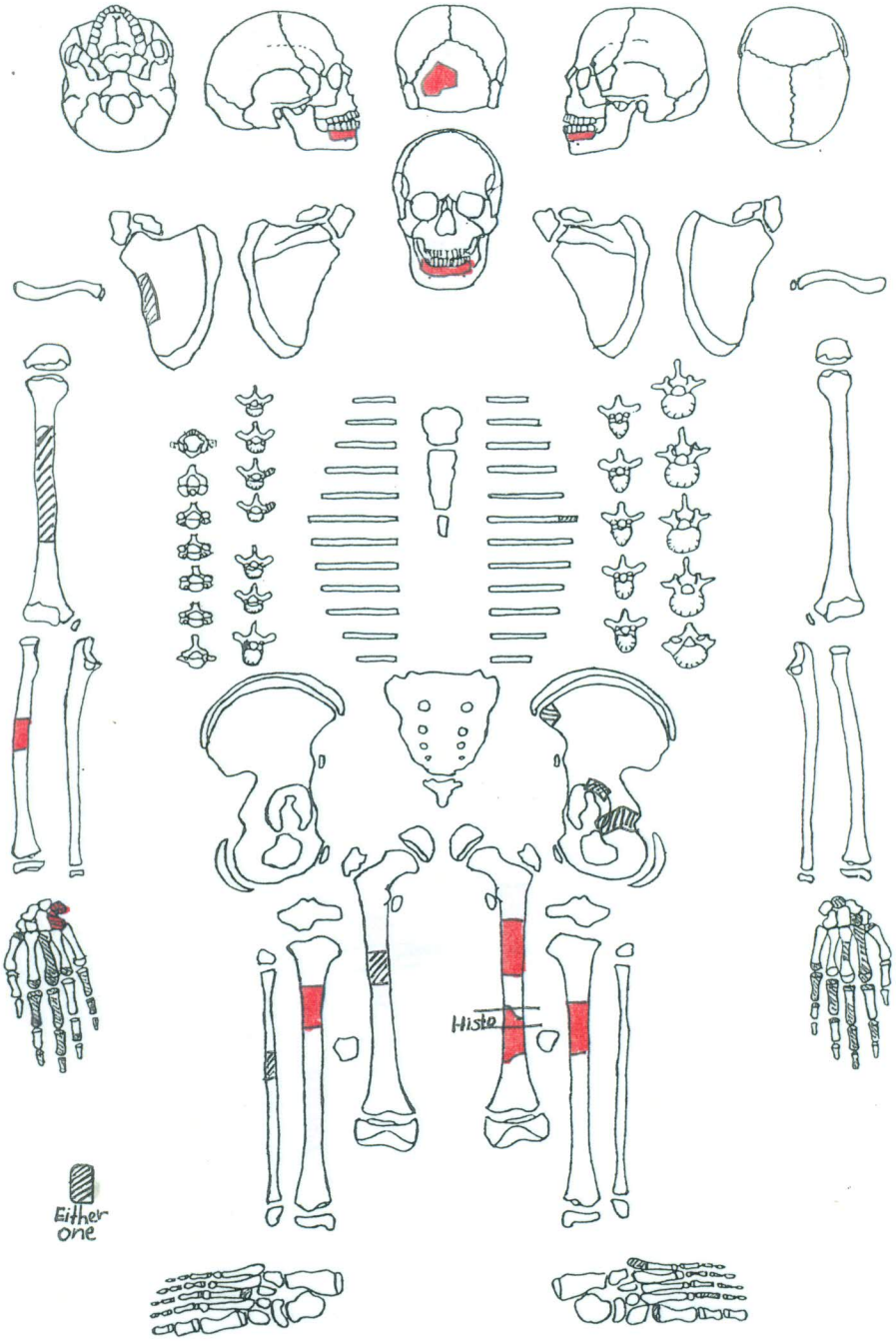


FIGURE 7: Diagrammatic inventory showing the state of preservation of subadult G35a.018 A.

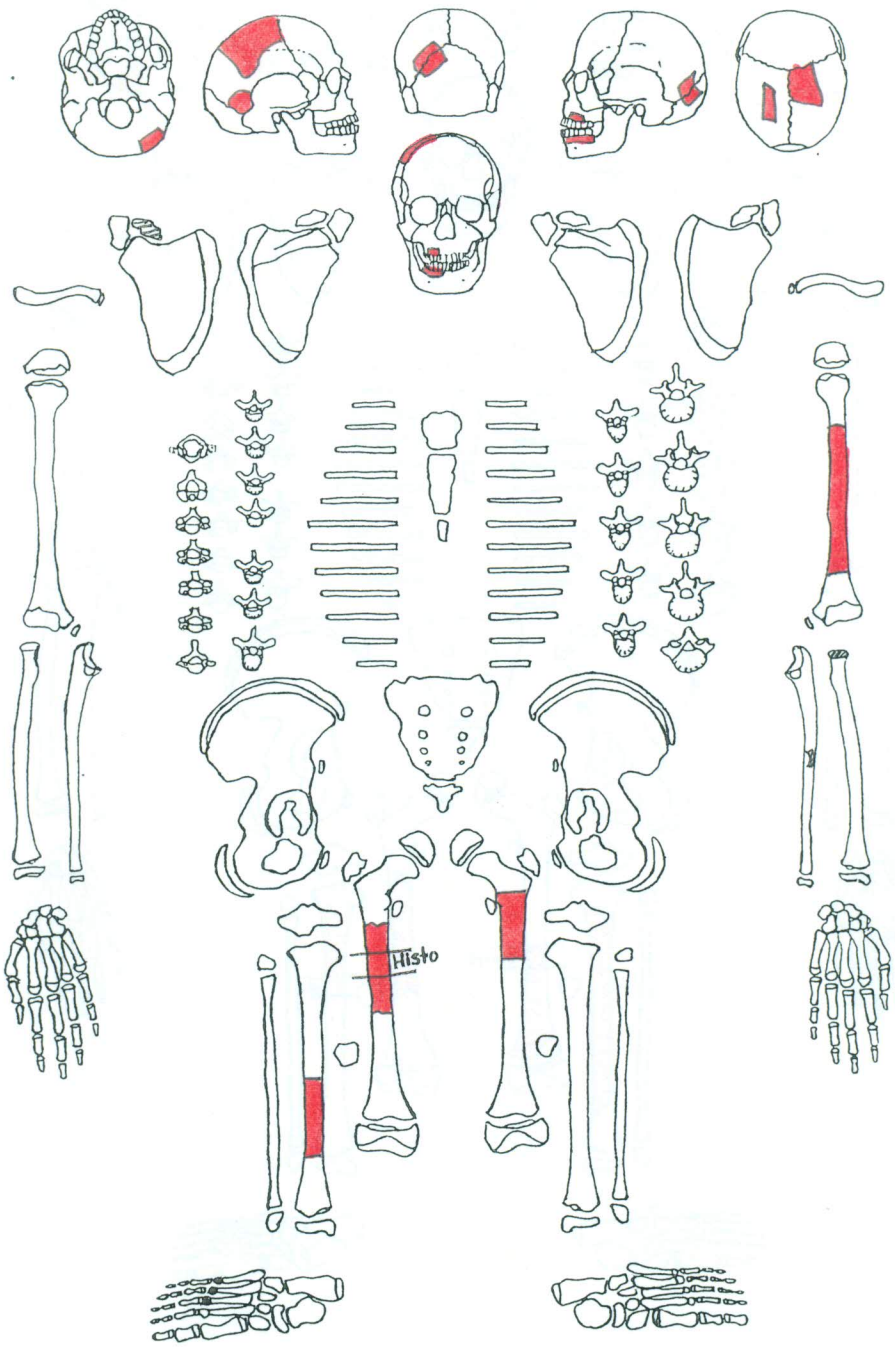


FIGURE 8: Diagrammatic inventory showing the state of preservation of subadult G35a.018 B.

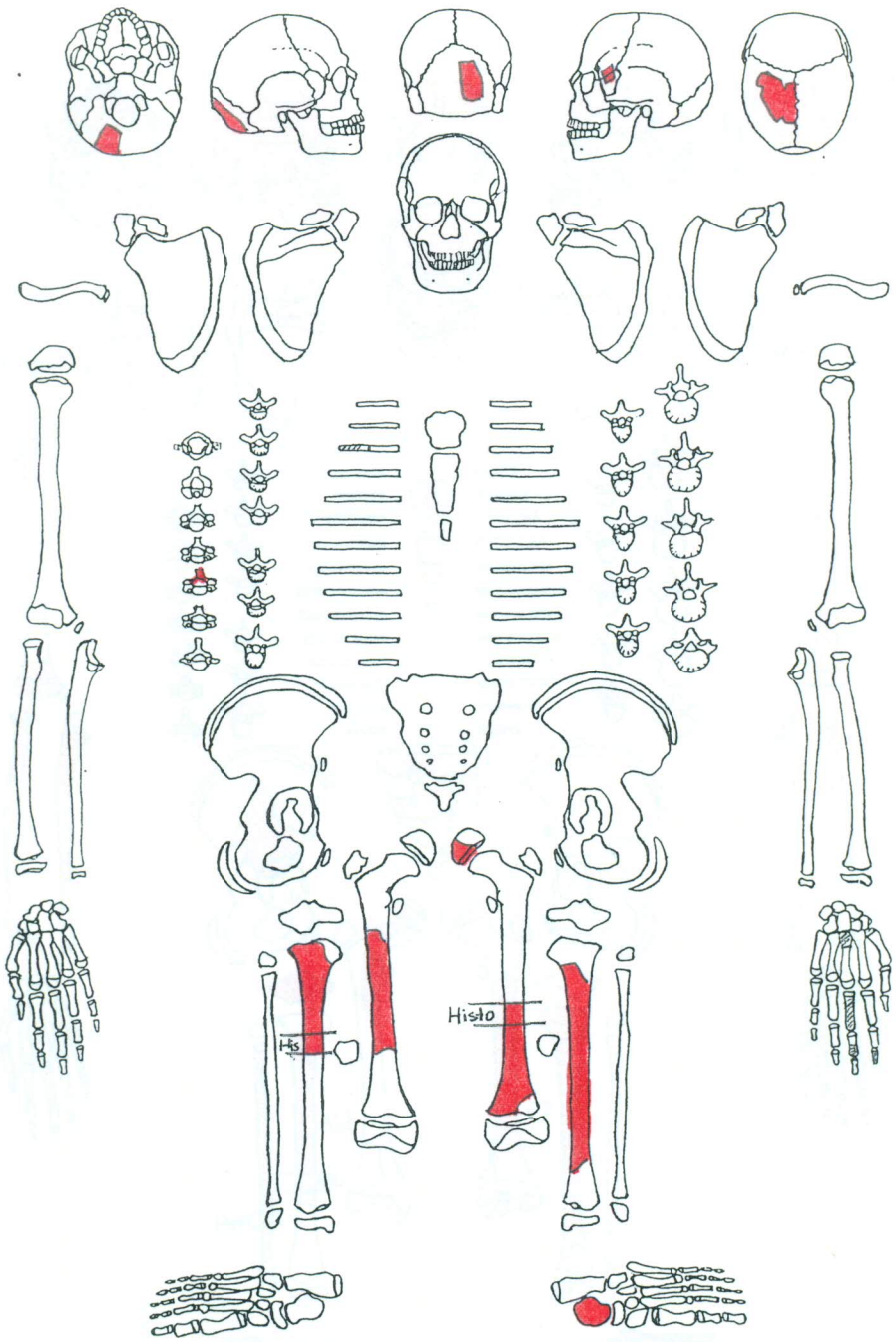


FIGURE 9: Diagrammatic inventory showing the state of preservation of juvenile G35b.003.

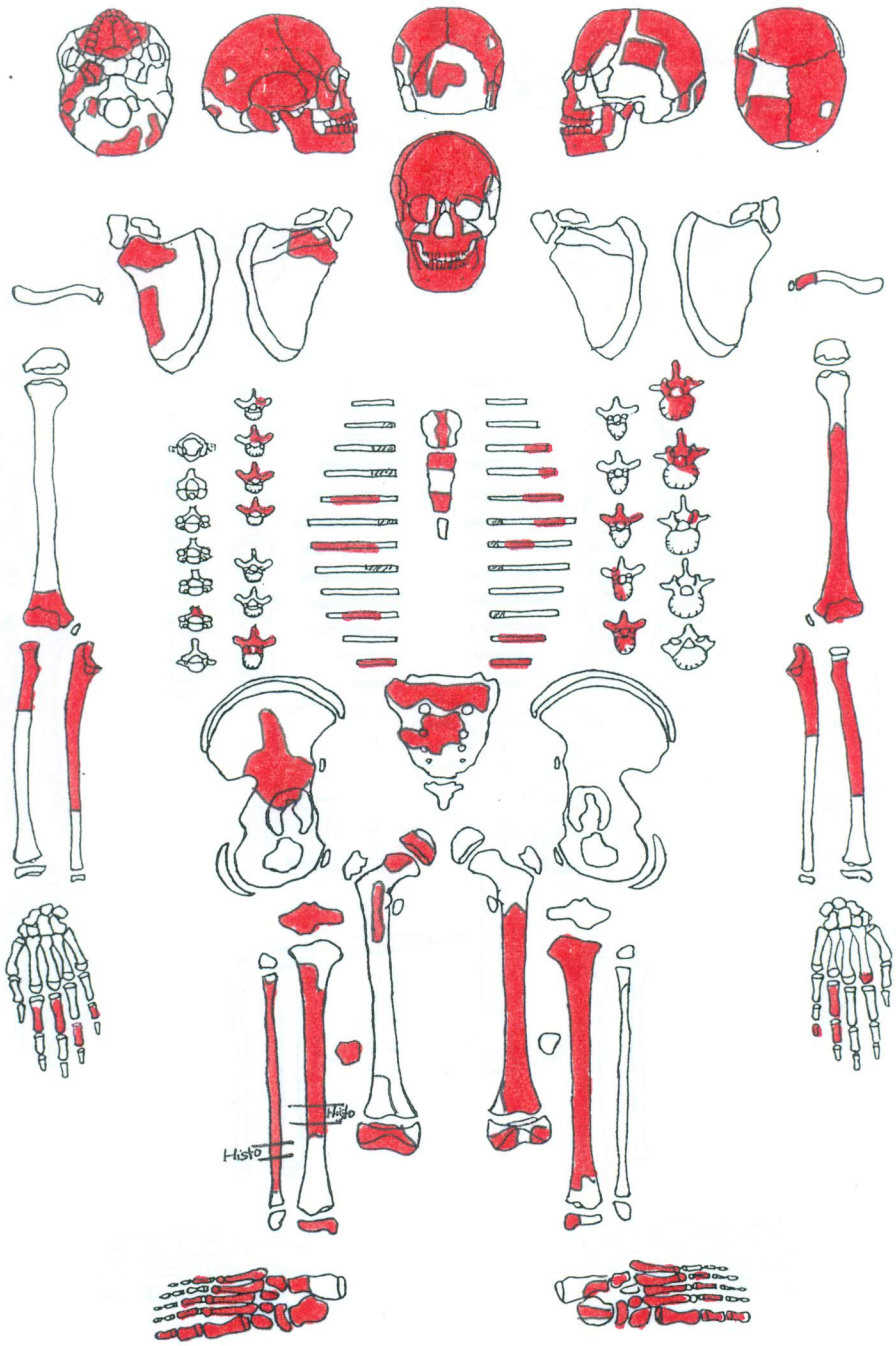


FIGURE 10: Diagrammatic inventory showing the state of preservation of subadult F34.026.

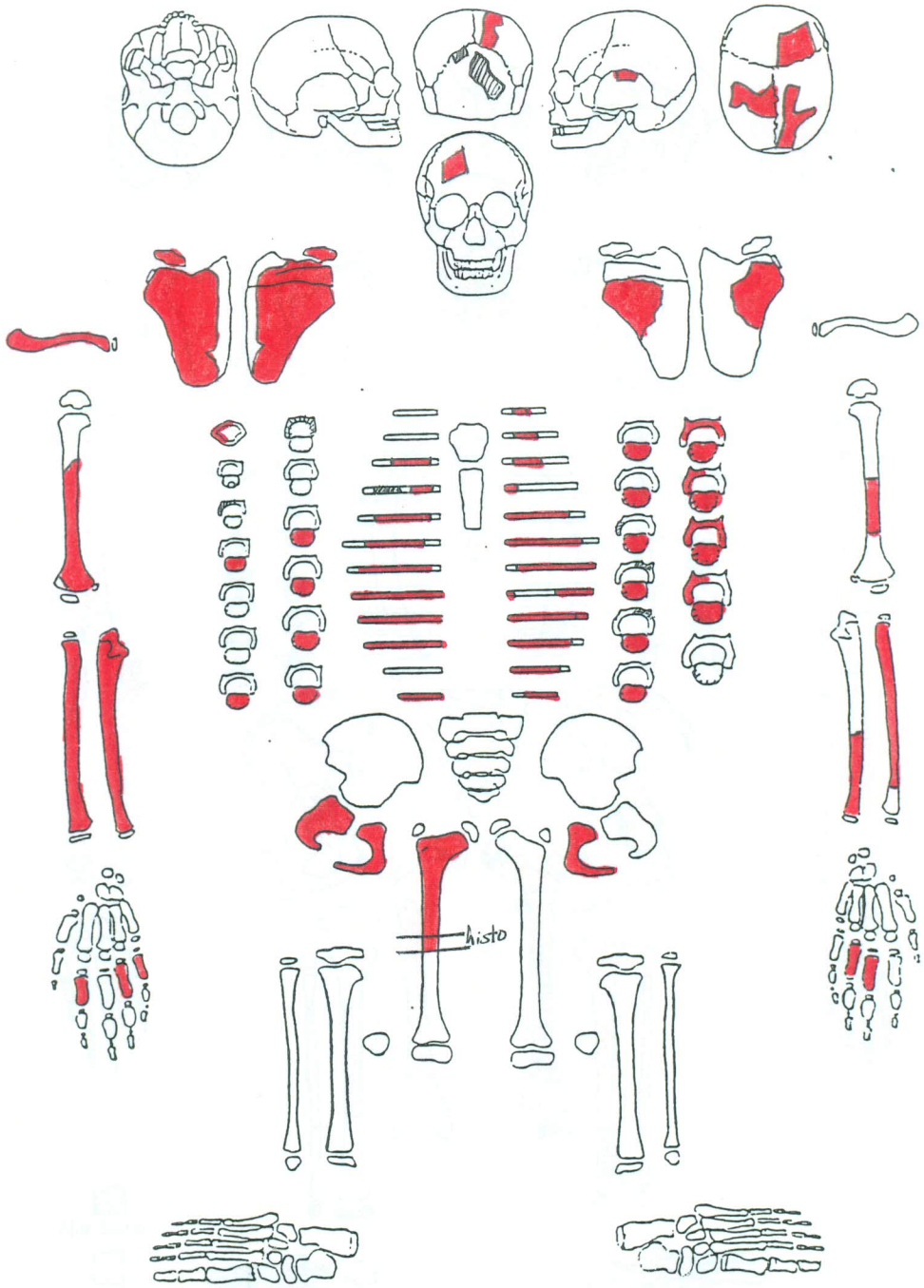


FIGURE 11: Diagrammatic inventory showing the state of preservation of infant F34.026.

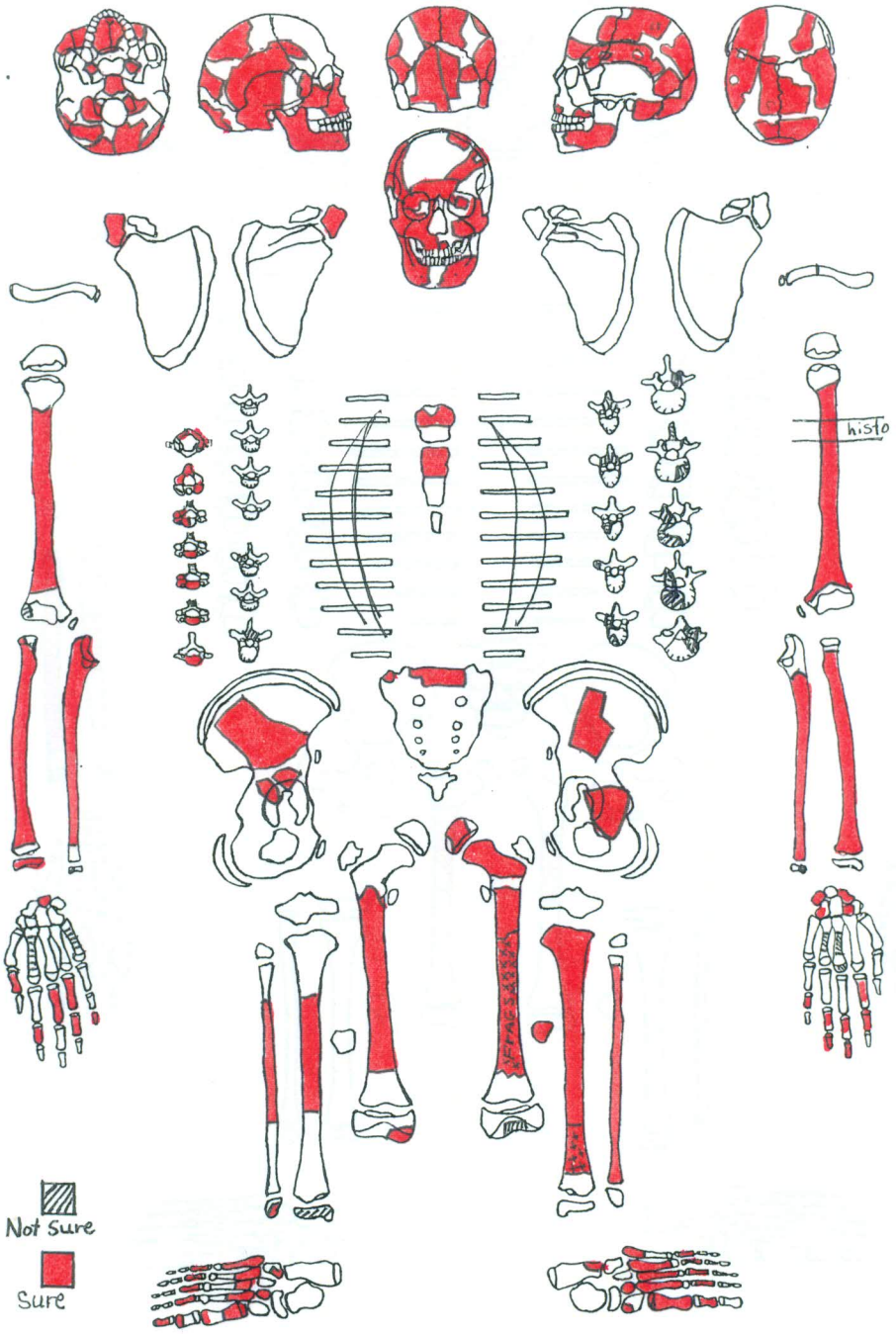


FIGURE 12: Diagrammatic inventory showing the state of preservation of juvenile E35.022.

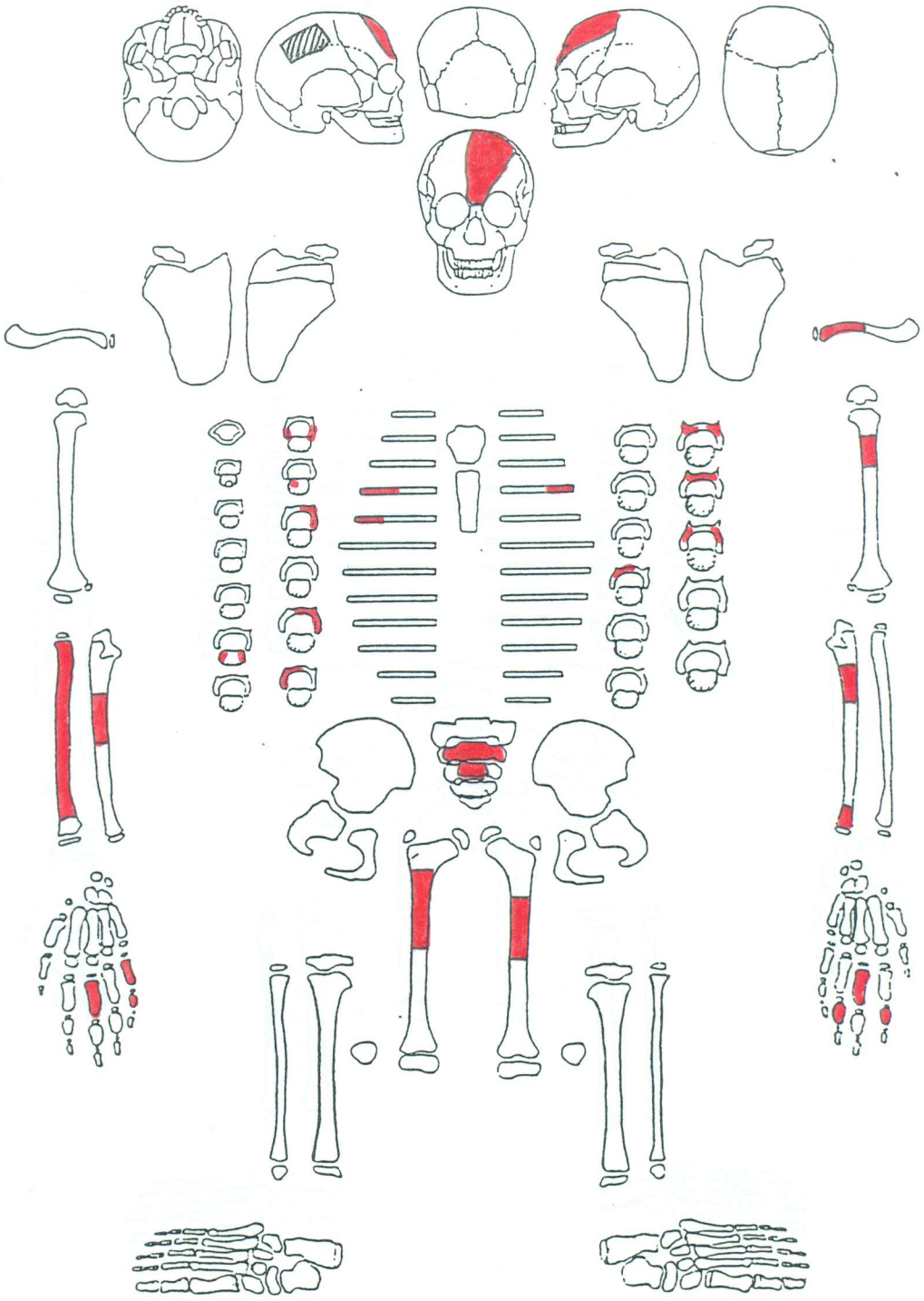


FIGURE 13: Diagrammatic inventory showing the state of preservation of juvenile E36a.026.

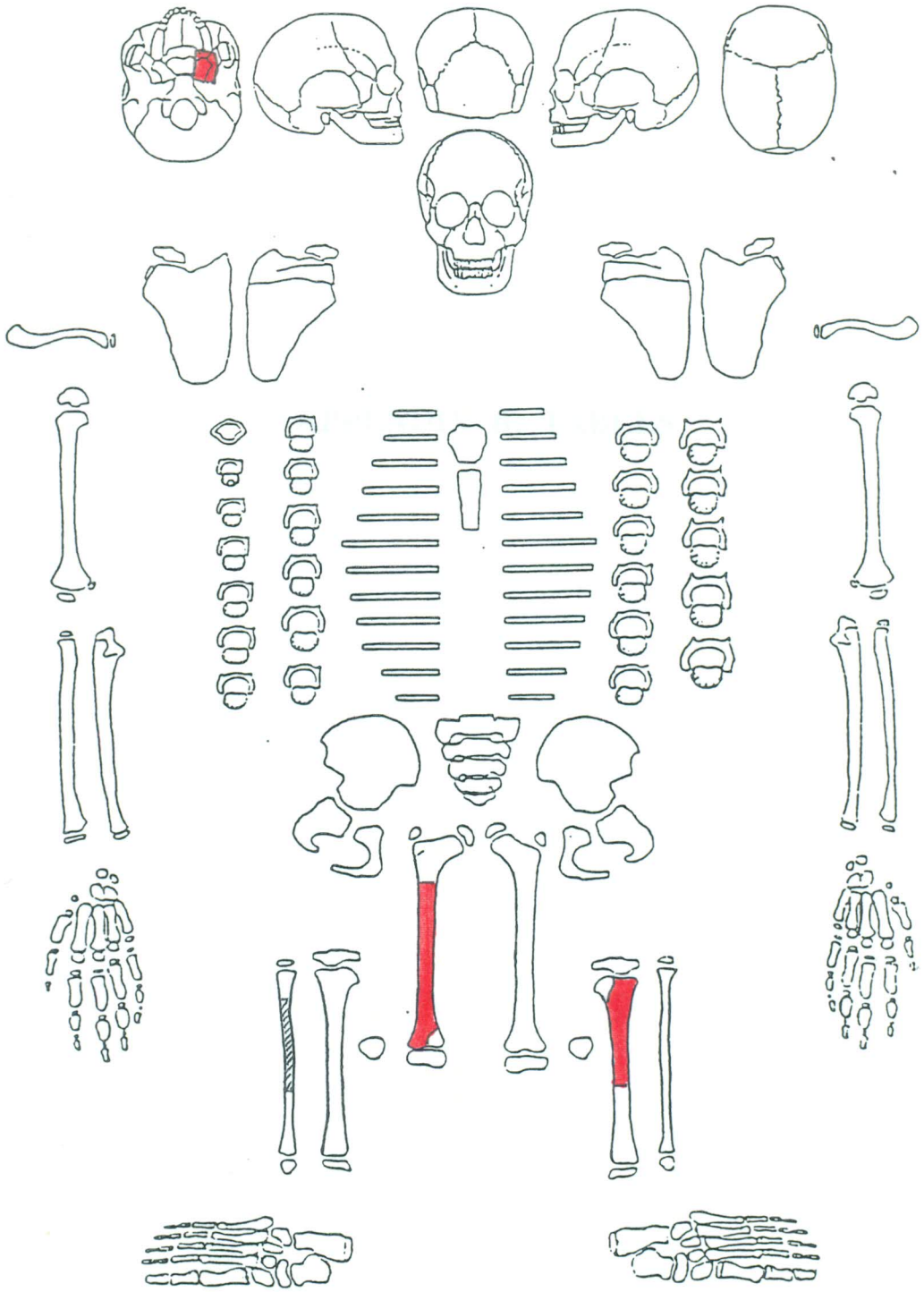


FIGURE 14: Diagrammatic inventory showing the state of preservation of infant E36b.016

APPENDIX B: TABLES

ESTIMATION OF AGE

TABLE -4- Estimation of Age for juvenile G34.022.

Site Name: WZ 200
Locus Number: 022
Individual: Juvenile

Grave Name: G34
Excavation Year: 1990

Age group:	Age Estimation
1- Appearance and fusion of epiphyses	There are no fusion of any of the epiphyses, including the *os coxae*. This gives a young age of below 12 years old, which at this age fusion of the *os coxae* starts (Bass 1987).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	The second molar did not emerge indicating an age below 11 years.
B- Ubelaker table (1989:71)	Age estimated at 6 years ± 24 months.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Stages of M1 root formation = R ½ which gives an age for girl = 5.4 and boy = 5.5; Stage of M2 crown formation = Cr ¾ gives an age for girl = 5.8 and boy = 6.1 years old.
3- Dental Attrition (Brothwell 1992:72)	Not applicable since there was only M1, rest are deciduous teeth.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	There is no complete long bone to be used in this method.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Not applicable.
6- Cranial Suture Closure (Meindl and Lovejoy)	Not applicable.
7- Ilium Auricular Surface (Lovejoy et al.)	Not applicable.
8- Pubic Symphyses (Suchey-Brooks)	Not applicable.
Average Age from the above methods:	An average age for both a girl and a boy: between 5 to 6 years old.

ESTIMATION OF AGE

TABLE -5- Estimation of age for subadult G35a.018A.

Site Name: WZ 200
Locus Number: 018
Individual: Subadult A

Grave Name: G35a
Excavation Year: 1992

Age group:	Age Estimation
1- Appearance and fusion of epiphyses.	The only complete bones to be used in this method were the metatarsal and metacarpals which none of them have fused. Beginning of MC fusion for female = 15-16 years and male = 18-19 years; beginning of MT fusion for female and male = 17-20 years old (William & Warwick 1980).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	Emergence of M2 in girls: 11.43 years old. Emergence of M2 in boys: 11.69 years old.
B- Ubelaker table (1989:71)	Age estimated at12 years ± 36 months.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Stage of M2 root formation = Rc which gives an age for girl = 11.8 and boy = 12.3; Stage of M3 crown formation = Ri gives an age for girl = 13.2 and boy = 13.2 years old.
3- Dental Attrition (Brothwell 1992:72)	17-25 year old.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	There was no complete bone to be used in this method.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Only one sternal end found that was eroded and could be to either individual; therefore, it was not used.
6- Cranial Suture Closure (Meindl and Lovejoy)	Cranium very fragmented.
7- Ilium Auricular Surface (Lovejoy et al.)	Not preserved.
8- Pubic Symphyses (Suchey-Brooks)	Not preserved
Average Age from the above methods:	An average age for both a girl and a boy: between 12 to 13 with a maximum of 15 years old.

ESTIMATION OF AGE

TABLE -6- Estimation of age for subadult G35a.018B.

Site Name: WZ 200
Locus Number: 018
Individual: Subadult B

Grave Name: G35a
Excavation Year: 1992

Age group: Subadult

Age Estimation

1- Appearance and fusion of epiphyses	The only complete bones to be used in this method were the metatarsal and metacarpals which none of them have fused. Beginning of MC fusion for female = 15-16 years and male = 18-19 years; beginning of MT fusion for female and male = 17-20 years old (William & Warwick 1980).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	Emergence of M2 in girls: 11.43 years old. Emergence of M2 in boys: 11.69 years old
B- Ubelaker table (1989:71)	Age estimated at 12 years ± 36 months.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Stage of M2 root formation = A ½ which gives an age for girl = 13.5 and boy = 13.9; Stage of M3 crown formation = Cli gives an age for girl = 14.1 and boy = 14.1 years old.
3- Dental Attrition (Brothwell 1992:72)	17-25 years old.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	There was no complete bone to be used in this method.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Only one sternal end found that was eroded and could be to either individual; therefore, it was not used.
6- Cranial Suture Closure (Meindl and Lovejoy)	Cranium very fragmented.
7- Ilium Auricular Surface (Lovejoy et al.)	Not preserved.
8- Pubic Symphyses (Suchey-Brooks)	Not preserved.
Average Age from the above methods:	An average age for both a girl and a boy: between 13 to 14 with a maximum of 15 years old.

ESTIMATION OF AGE

TABLE -7- Estimation of age for juvenile G35b.003.

Site Name: WZ 200
Locus Number: 003
Individual: Juvenile

Grave Name: G35b
Excavation Year: 1992

Age group:	Age Estimation
1- Appearance and fusion of epiphyses	There are no fusion of any of the epiphyses, including the *os coxae*. This gives a young age of below 12 years old, which at this age fusion of the *os coxae* starts (Bass 1987).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	The second molar did not emerge indicating an age below 11 years.
B- Ubelaker table (1989:71)	Age estimated at 8 years ± 24 months.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Stage of M2 root formation = R1/4 which gives an age for girl = 9.5 and boy = 9.8 years old.
3- Dental Attrition (Brothwell 1992:72)	Not applicable since only one M2 present, rest lost postmortem.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	There is no complete long bone to be used in this method.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Not applicable.
6- Cranial Suture Closure (Meindl and Lovejoy)	Not applicable.
7- Ilium Auricular Surface (Lovejoy et al.)	Not applicable.
8- Pubic Symphyses (Suchey-Brooks)	Not applicable.
Average Age from the above methods:	An average age for both a girl and a boy: between 8 to 10 years old.

ESTIMATION OF AGE

TABLE -8- Estimation of age for subadult F34.026.

Site Name: WZ 200
Locus Number: 026
Individual: Subadult

Grave Name: F34
Excavation Year: 1992

Age group:	Age Estimation
1- Appearance and fusion of epiphyses	There is no fusion of any epiphyses. The distal humerus gives a young age for unsexed individuals of around 9-11years (Buikstra & Ubelaker 1994:43). The ilium was not fused to both ischium and pubic, giving an age range with the start of fusion at 12 to complete by 17 years (Bass 1987:187).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245).	Emergence of M2 in girls: 11.43 years old. Emergence of M2 in boys: 11.69 years old
B- Ubelaker table (1989:71)	Age estimated around 21 year since the third mandibular molar has erupted.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Stage of M3 root formation = R¾ which gives an age for girl = 16.9 and boy = 16.4 years old.
3- Dental Attrition (Brothwell 1992:72)	17-25 years
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	F34 does not have a complete long bone to be used in this method.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	First phase: if male: 17-19 years, and if female: 14-15 years old.
6- Cranial Suture Closure (Meindl and Lovejoy)	Not visible due to calcite encrustation on the cranium surface.
6- Ilium Auricular Surface (Lovejoy et al.)	Not preserved
7- Pubic Symphyses (Suchey-Brooks)	Not preserved
Average Age from the above methods:	An average age as a girl: between 14 to 16 with maximum of 18 years old; and as a boy: between 16 to 18 with a maximum of 19 years old.

ESTIMATION OF AGE

TABLE -9- Estimation of age for infant F34.026.

Site Name: WZ 200
Locus Number: 026
Individual: Infant

Grave Name: F34
Excavation Year: 1992

Age group:	Age Estimation
1- Appearance and fusion of epiphyses	There was no fusion of any epiphyses. An estimated age can be given according to the development stages that the vertebrae have reached, which the cervical and thoracic vertebrae neural arches were unfused, giving a maximum age of around 2 years (Buikstra & Ubelaker 1994:43).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	The maxillae and mandible were not preserved to assess the eruption of the teeth and only isolated teeth were present; therefore, no age is given here.
B- Ubelaker table (1989:71)	There were no wear facets on any of the occlusal surfaces indicating uneruption. The first maxillary molar root formation gives an age of 9 months ± 3 months.
C- Moorrees et al (1963a, 1963b) tables	Stages of both mandibular canines and second molar crown formation = Crc which gives an age for girl = 7months and boy = 7 months old.
3- Dental Attrition (Brothwell 1992:72)	None.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	The right radius and ulna are complete, but fragmented into several pieces that can be reconstructed and used to give an age estimate of between 0.5 months to 1Y.5 months old.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Not applicable.
6- Cranial Suture Closure (Meindl and Lovejoy)	Not applicable.
7- Ilium Auricular Surface (Lovejoy et al.)	Not applicable.
8- Pubic Symphyses (Suchey-Brooks)	Not applicable.
Average Age from the above methods:	An average age for both a girl and a boy: between 0.7 to 0.9 months, with a maximum of 1 year and 5 months.

ESTIMATION OF AGE

TABLE -10- Estimation of age for juvenile E35.022.

Site Name: WZ 200
Locus Number: 022
Individual: Juvenile

Grave Name: E35
Excavation Year: 1990

Age group:	Age Estimation
1- Appearance and fusion of epiphyses	There are no fusion of any of the epiphyses, including the *os coxae*. This gives a young age of below 12 years old, which at this age fusion of the *os coxae* starts (Bass 1987).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	Emergence of M2 in girls: 11.43 years old. Emergence of M2 in boys: 11.69 years old.
B- Ubelaker table (1989:71)	Age estimated at 12 years ± 36 months.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Stages of M2 root formation = Rc which gives an age for girl = 11.8 and boy = 12.3 years old.
3- Dental Attrition (Brothwell 1992:72)	Not applicable for being younger than 17 years.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	There is no complete long bone to be used in this method.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Not applicable.
6- Cranial Suture Closure (Meindl and Lovejoy)	Not applicable.
7- Ilium Auricular Surface (Lovejoy et al.)	Not applicable.
8- Pubic Symphyses (Suchey-Brooks)	Not applicable.
Average Age from the above methods:	An average age for both a girl and a boy: between 11 to 12 years old.

ESTIMATION OF AGE

TABLE -11- Estimation of age for juvenile E36a.026.

Site Name: WZ 200
Locus Number: 026
Individual: Juvenile

Grave Name: E36a
Excavation Year: 1990

Age group:	Age Estimation
1- Appearance and fusion of epiphyses	There are no fusion of any of the epiphyses, including the *os coxae*. This gives a young age of below 12 years old, which at this age fusion of the *os coxae* starts (Bass 1987).
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	The second molar did not emerge indicating an age below 11 years.
B- Ubelaker table (1989:71)	Age estimated at 6 years ±24 months.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Stages of M2 crown formation = Crc which gives an age for girl = 6.6 and boy = 6.8; Stage of canine root formation = Ri gives an age for girl = 5.0 and boy = 5.2 years old.
3- Dental Attrition (Brothwell 1992:72)	Not applicable.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	There is no complete long bone to be used in this method.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Not applicable.
6- Cranial Suture Closure (Meindl and Lovejoy)	Not applicable.
7- Ilium Auricular Surface (Lovejoy et al.)	Not applicable.
8- Pubic Symphyses (Suchey-Brooks)	Not applicable.
Average Age from the above methods:	An average age for both a girl and a boy: between 5 to 6 with maximum of 7 years old.

ESTIMATION OF AGE

TABLE -12- Estimation of age for infant E36b.016.

Site Name: WZ 200
Locus Number: 016
Individual: Infant

Grave Name: E36b
Excavation Year: 1990

Age group:	Age Estimation
1- Appearance and fusion of epiphyses	There was no fusion of any epiphyses, indicating a very young age.
2- Dental formation, calcification and eruption. Methods: A- El-Nofely and Iscan (1989:241-245)	There were no teeth preserved to be used in this method.
B- Ubelaker table (1989:71)	Not applicable, no teeth.
C- Moorrees et al (1963a, 1963b) tables and Smith (1991:161)	Not applicable, no teeth.
3- Dental Attrition (Brothwell 1992:72)	Not applicable, no teeth.
4- Diaphyseal length of long bones (Ubelaker 1989a: 70-71)	There was no complete bone to be used in this method, however, an approximation indicates prenatal age.
5- Sternal Ends of Ribs (Loth and Iscan 1989)	Not applicable.
6- Cranial Suture Closure (Meindl and Lovejoy)	Not applicable.
7- Ilium Auricular Surface (Lovejoy et al.)	Not applicable.
8- Pubic Symphyses (Suchey-Brooks)	Not applicable.
Average Age from the above methods:	An estimated age is difficult to give, since the remains are very poorly preserved with only few fragmented bones. The average size when compared to British populations indicates around prenatal age.

DENTAL CHART

TABLE -14- Dental chart for juvenile G34.022.

Site Name: WZ200
Locus Number: 022
Individual: Juvenile

Grave Name: G34
Excavation Year: 1990

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost postmortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken postmortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal	Hypoplasia	Caries
in: Inflammatory	p: Pit-like lines	c: Crown
no: non-Inflammatory	g: Groove	n: Neck

Right Left

Hypoplasia																
Attrition			1	3-	4	2		4	4	3	3		3-	1		
Caries																
Calculus																
Periodontal																
Maxillary		u	16	57	56	53	p	51	61	62	63	p	67	26	u	
Mandibulary		u	46	87b	86b	b	82	p	71	p	73	76	77	36	u	
Periodontal																
Calculus																
Caries																
Attrition			2	3	3-		4		3		2+	3-	3	2		
Hypoplasia																

Enamel Hypoplasia

None was found on the deciduous teeth.	

Anomalies and Variations

1- Postmortem breakage to the anterior part of the maxilla exposed the unerupted permanent first right incisor with 2 hypoplasia grooves, that occurred around the age of 3 years old.
g: 11(3Y±12mos, grade II).

2- The right and left first permanent maxillary molars had the genetic trait of Carabelli cusp.

3- The right and left second unerupted permanent maxillary molars had dark brown discoloration, that might be caused postmortem.

DENTAL CHART

TABLE -15- Dental chart for subadults G35a.018A.

Site Name: WZ200
Locus Number: 018
Individual: Subadult

Grave Name: G35a
Excavation Year: 1992

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost postmortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken postmortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal	Hypoplasia	Caries
in: Inflammatory	p: Pit-like lines	c: Crown
no: non-Inflammatory	g: Groove	n: Neck

Right Left

Hypoplasia					2gs III			5 gs III	5gs II	5gs III		2gs II				
Attrition				1	2			4	3	3		2+	1	3-	2	
Caries																
Calculus																
Periodontal																
Maxillary	xx	xx	xx	15	14	xx	xx	11	21	22	xx	24	25b	26	27	xx
Mandibulary	u	47	46	xx	44	43	42b	41	xx	32b	33	34	35	36	37	u
Periodontal																
Calculus		~L			~ B	~M-B	I M-B-D-L	I M-B-D-L		I M-B-D-L	~D					
Caries																
Attrition		2	3-		2+	2	3	4		3	2	2	2	3-	2	
Hypoplasia		g II	2gs II		3gs III	6gs IV	g II	g II		g II	6gs IV	g III	2gs III			

Enamel Hypoplasia

g: 47(6Y±24mos, grade II). g: 46(3Y±12mos, grade II). *(44) had three grooves in sequence occurring between the ages 5 to 6 years old. g1:44(5Y±16mos, grade III); g3:44(6Y±24mos, grade III). *(43) had six grooves in sequence occurring between the ages of 3 to 6 years, with g3 being the deepest with grade V; g1-g2 grade IV and g4-6 grade III: g1:43(3Y±12mos, grade IV); g3: 43(4Y±12mos, grade V); g5:43(5Y±16mos, grade III); g6:43(6Y±24mos, grade III). g: 42(2Y±8mos, grade II). g: 41(2Y±8mos, grade II). g: 32(2Y±8mos, grade II). *(33) had six grooves in sequence occurring between the ages 3 to 6 years, with g3 being the deepest with grade V; g1-g4 grade IV and g4&5 grade III: g1: 33(3Y±12mos, grade IV); g3: 33(4Y±12mos, grade V); g5: 33(5Y±16mos, grade III); g6: 33(6Y±24mos, grade III). *(34) had three grooves in sequence occurring between the ages 5 to 6 years old. g1:34(5Y±16mos, grade III); g3:34(6Y±24mos, grade III). g1:35(6Y±24mos, grade IV); g2:35(7Y±24mos, grade IV).	g1: 14(5Y±16mos, grade III), g2 just in sequence after g1. *(11) had five grooves in sequence occurring between the ages 18 months to 3 years old. g1:11(9mos±6mos, grade II), g2:11(2Y±8mos,grade III); g3&4 are in sequence; g5:11(3Y±12mos, grade II). *(21) had five grooves in sequence occurring between the ages 2 to 3 years old, all have the same grade II. g1:21(2Y±8mos, grade II), g2-4 are in sequence; g5:21(3Y±12mos, grade II). *(22) had five grooves in sequence occurring between the ages 2 to 4 years old, all have the same grade III. g1:22(2Y±8mos, grade III); g5:22(4Y±12mos, grade II). g1:24(5Y±16mos, grade III), g2 just in sequence after g1.

Anomalies and Variations

1- The two maxillary central incisors have a groove at their mid-occlusal surfaces. On the labial surface there was the evidence of some kind of activity had polished and smoothed the labial enamel surface, thus reducing the various degrees the hypoplastic grooves.

2- The left maxillary lateral incisor have the Asian genetic trait of shovel-shaping.

DENTAL CHART

TABLE -16- Dental chart for subadult G35a.018B.

Site Name: WZ200
Locus Number: 018
Individual: Subadult B

Grave Name: G35a
Excavation Year: 1992

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost postmortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken postmortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal	Hypoplasia	Caries
in: Inflammatory	p: Pit-like lines	c: Crown
no: non-Inflammatory	g: Groove	n: Neck

Right Left

Hypoplasia				g II	3gs IV	3gs III		4gs V	2gs 2ps		1g 3p	2ps III	g II	2gs II	g I	
Attrition			3-	1	1	2		3	3		2	1	1	3-	2	
Caries																
Calculus					I B	~ B					~B	~B				
Periodontal																
Maxillary	xx	xx	16	15b	14	13	xx	11	21	22b	23	24b	25b	26	27b	xx
Mandibulary	u	47	46	45	44	43b	42b	xx	xx	xx	33	xx	xx	xx	xx	xx
Periodontal																
Calculus		~L -D	~L -D			~B	I M-B-D				~B					
Caries																
Attrition		2	3-	2	1	2	2				2					
Hypoplasia				g I	2gs II	5gs III	3gs II				5gs III					

Enamel Hypoplasia

g:45(6Y±24mos, grade I). g1:44(5Y±16mos, grade II); g2 just in sequence after g1. *(43) had five grooves in sequence occurring between the ages of 3 to 6 years, g1&2 have grade IV and g3-5 have grade III. g1:43(3Y±16mos, grade IV); g5:43(6Y±24mos, grade III). *(42) had three grooves in sequence occurring between the ages of 3 to 5years, all of grade II: g1: 42(3Y±12mos, grade II); g3: 42(5Y±16mos, grade II). *(33) had five grooves in sequence occurring between the ages of 3 to 6 years, g1&2 have grade IV and g3-5 have grade III. g1:33(3Y±16mos, grade IV); g5:33(6Y±24mos, grade III).	g:15(6Y±24mos, grade II). *(14) had three grooves in sequence occurring between the ages of 5 to 6 years, g1 grade III, and g2&3 grade IV. g1:14(5Y±16mos, grade III), g2 just in sequence after g1 with grade VI; g3:14(6Y±24mos, grade IV). *(13) had three grooves in sequence occurring between the ages of 5 to 6 years, g1-3 have grade III, and a pit-like line just after g3 with grade III. g1:13(5Y±16mos, grade III), p:13(6Y±24mos, grade III). *(11) had four grooves in sequence occurring between the ages of 3 to 4 years, all have grade V. g1:11(3Y±12mos, grade V); g2:11(4Y±12mos, grade V). *(21) had two grooves in sequence occurring within the age of 3 with grade IV, and two pit-like line occurring within the age of 4 years with grade III. g1:21(3Y±12mos, grade IV); p2:11(4Y±12mos, grade III). *(23) had one groove occurred around the age of 4 years, with grade II. Three pit-like lines in sequences occurring after g1 within age 4 until 6 years with grade IV. g1:23(4Y±12mos, grade II); p3:23(6Y±24mos, grade IV). p1:24(5Y±16mos, grade III); p2 occurring with age 5 and just in sequence after p1 with grade III. g:35(6Y±24mos, grade II). g1:26(2Y±8mos, grade II); g2:26(3Y±12mos, grade II). g:27(6Y±24mos, grade I).

Anomalies and Variations

1- The two maxillary central incisors have a groove at their mid-occlusal surfaces. On the labial surface there was the evidence of some kind of activity had polished and smoothed the labial enamel surface, thus reducing the various degrees the hypoplastic grooves.

DENTAL CHART

TABLE -17- Dental chart for juvenile G35b.003.

Site Name: WZ200
Locus Number: 003
Individual: Juvenile

Grave Name: G35b
Excavation Year: 1992

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost postmortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken postmortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal	Hypoplasia	Caries
in: Inflammatory	p: Pit-like lines	c: Crown
no: non-Inflammatory	g: Groove	n: Neck

Right Left

Hypoplasia															
Attrition															
Caries															
Calculus															
Periodontal															
Maxillary															
Mandibulary														37u	
Periodontal															
Calculus															
Caries															
Attrition															
Hypoplasia															

Anomalies and Variations

1- Only one tooth was present, the second permanent mandibulary molar.

DENTAL CHART

TABLE -18- Dental chart for subadult F34.026.

Site Name: WZ200
Locus Number: 026
Individual: Subadult

Grave Name: F34
Excavation Year: 1992

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost post-mortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken post-mortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal
in: Inflammatory
no: non-Inflammatory

Hypoplasia
p: Pit-like lines
g: Groove

Caries
c: Crown
n: Neck

Right Left

Hypoplasia		g II	g I	g I	g I	3gs II	g I	g I	g I	g I	3gs II	2gs II	g I	g I		
Attrition		2	3-	2	2	1	1	1	1	2	2	1	1	2+	2	
Caries																
Calculus																
Periodontal																
Maxillary	xx	17	16	15	14	13	12	11	21	22	23	24	25	26	27b	xx
Mandibulary	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
Periodontal																
Calculus		I L	~ L					~M-L	~M-L	~M-L			~ L-D	I L-D	I L-D	
Caries																
Attrition	1	2	3	4	4	3	3	4	4	3	3	2	3	3	2	1
Hypoplasia				g II	g II	2gs II	2gs II	g II	g II	2gs II	2gs II	g II	g I g II			

Enamel Hypoplasia

g: 45(6Y±24mos, grade II). g: 44(5Y±16mos, grade II). g1: 43(3Y±12mos; grade II) g2: (4Y±12mos, grade IV). g1:42(2Y±8mos, grade II); g2: 42(3Y±12mos, grade II). g: 41(3Y±12mos, grade II). g: 31(3Y±12mos, grade II). g: 32(2Y±8mos, grade II); g2: 32(3Y±12mos, grade II). g1: 33(3Y±12mos; grade II) g2: (4Y±12mos, grade IV). g: 34(5Y±16mos, grade II). g: 35(5Y±16mos, grade II); t: (6Y±24mos, grade III).	g: 17(7Y±24mos, grade II). g: 16(3Y±12mos, grade I). g: 15(6Y±24mos, grade I). g: 14(5Y±16mos, grade I). *(13) had three grooves in sequence occurring between the ages of 3 to 6 years old, with g2 being the deepest with grade III: g1:13(3Y±12mos, grade II); g3:13(6Y±24mos, grade II). g: 12(4Y±12mos, grade I). g: 11(3Y±12mos, grade I). g: 21(3Y±12mos, grade I). g: 22(4Y±12mos, grade I). *(23) had three grooves in sequence occurring between the ages of 3 to 6 years old, with g2 being the deepest with grade III: g1:23(3Y±12mos, grade II); g3:23(6Y±24mos, grade II). g1:24(5Y±16mos, grade II); g2:24(6Y±24mos, grade II). g: 25(5Y±16mos, grade I). g: 26(3Y±12mos, grade I).

Anomalies and Variations

1- Only the mandibular third molars were present, however, the right M3 has a small wear facet on the occlusal surface of the mesial-buccal cusp indicating the presence of a right maxillary upper molar.

2- There is a small space between 22 and 23 that measures at 0.38mm.

3- 12 has a smaller size than 22. There was a slight rotation of 12 to the mesial-lingual side making if to come closer to the distal side of 11.

4- The occlusal surface of 21 has a groove in the middle, indicating a kind of behaviour concentrated at that area in the dentition.

5- 11 was broken post-mortem, but cemented on the alveolar process, causing it to project forwards.

6- The two incisors, 22 and 12, have the Asian genetic shovel-shape trait.

7- The dental occlusion of the maxillae and the mandible of F34 was most likely edge-to-edge bite of the anterior teeth. As a result of the maxillae slight compression at the palatine suture, this made it difficult to place the maxillae and the mandible in the correct anatomical occlusion.

DENTAL CHART

TABLE -19- Dental chart for infant F34.026.

Site Name: WZ200
Locus Number: 026
Individual: Infant

Grave Name: F34
Excavation Year: 1992

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost postmortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken postmortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal	Hypoplasia	Caries
in: Inflammatory	p: Pit-like lines	c: Crown
no: non-Inflammatory	g: Groove	n: Neck

Right Left

Hypoplasia																
Attrition																
Caries																
Calculus																
Periodontal																
Maxillary			16u	xx	56u	xx	xx	xx	xx	xx	xx	xx	xx			
Mandibulary				xx	xx	83u	xx	81u	71u	xx	xx	xx	77			
Periodontal																
Calculus																
Caries																
Attrition																
Hypoplasia																

Anomalies and Variations

1- The teeth have discoloration of the enamel white colour that was replaced by brownish colour. It is speculated that the discoloration was the result of postmortem influences.

DENTAL CHART

TABLE -20- Dental chart for juvenile E35.022.

Site Name: WZ200
Locus Number: 022
Individual: Juvenile

Grave Name: E35
Excavation Year: 1990

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost postmortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken postmortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal	Hypoplasia	Caries
in: Inflammatory	p: Pit-like lines	c: Crown
no: non-Inflammatory	g: Groove	n: Neck

Right Left

Hypoplasia																
Attrition		1	2	3+		2	2	2	2	2	1		4	2	1	
Caries																
Calculus						~B		~A-D								
Periodontal																
Maxillary		17	16	57		13	12	11	21	22	23		67	26	27	
Mandibulary		47	46	87	44	43	42	41	31		33	34	77	36	37	
Periodontal																
Calculus							I M-L	I A-D-L-M	I A-D-L-M		II A-D-L					
Caries																
Attrition		1	2+	4	1	2	2	3	2		2	2	4	2	2	
Hypoplasia						g I										

Enamel Hypoplasia

g:43(3Y±12mos, grade I).	

Anomalies and Variations

1- In general the dentition of this juvenile was slightly smaller than the other juveniles and subadult dentition.

2- The maxillary left canine had a slightly smaller size than the right maxillary canine.

3- Congenital absence of the second premolar found in the right mandible.

DENTAL CHART

TABLE -21- Dental chart for juvenile E36a.026.

Site Name: WZ200
Locus Number: 026
Individual: Juvenile

Grave Name: E36a
Excavation Year: 1990

The chart is devised from Schultz (1988a)

Description:
m: Missing, alveolar closed, antemortem
p: Lost postmortem
xx: No bone or tooth (both lost)
--: Isolated tooth
b: Broken postmortem
s: Space more than normal
e: Erupting ; pe: Partially erupted
u: Unerupted

Caries
O: Occlusal ~: Traces
M: Mesial
D: Distal
B: Buccal
L: Lingual
P: Palate
A: Labial

Periodontal
in: Inflammatory
no: non-Inflammatory

Hypoplasia
p: Pit-like lines
g: Groove

Caries
c: Crown
n: Neck

Right Left

Hypoplasia																
Attrition				2	2	1				1						
Caries																
Calculus																
Periodontal																
Maxillary			16p	57	56	53				62						
Mandibulary			46p	86	86											
Periodontal																
Calculus																
Caries																
Attrition				2	1											
Hypoplasia																

APPENDIX C: PLATES

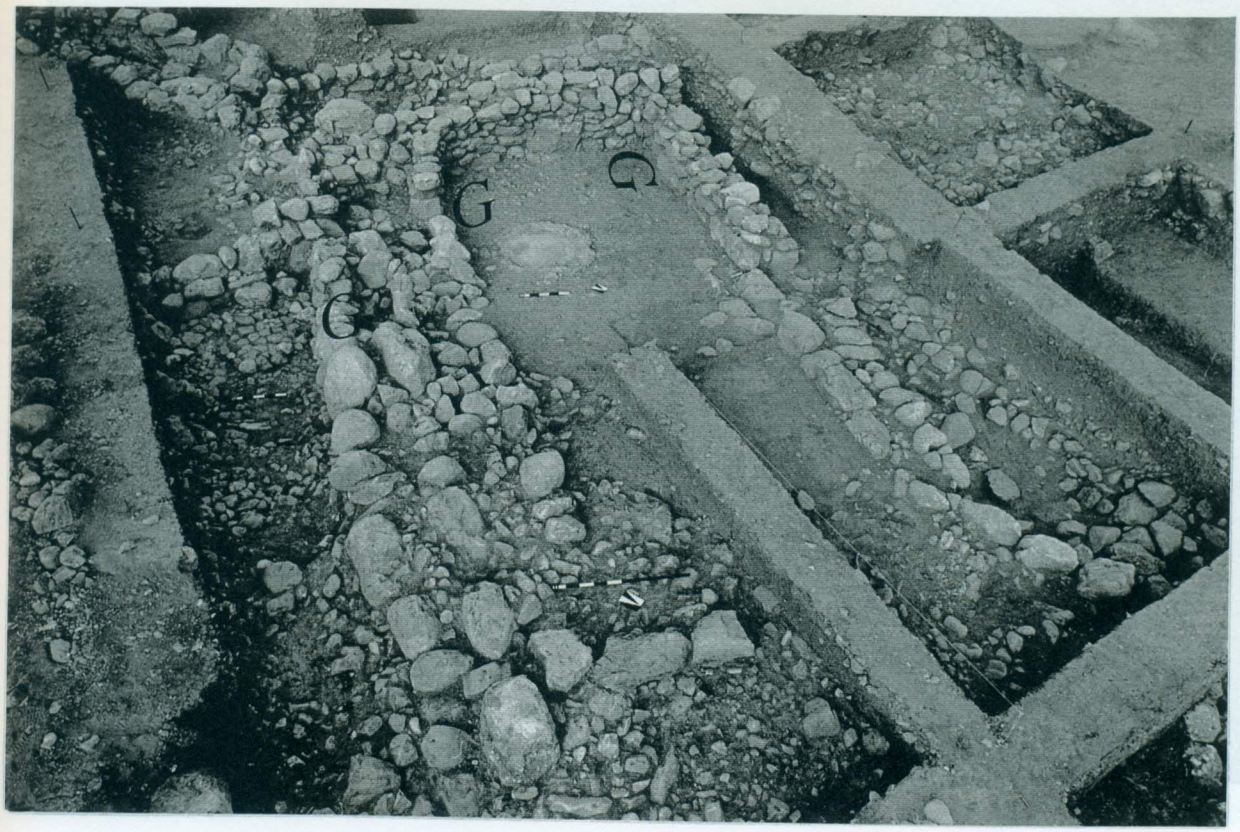


PLATE 1: Field photograph showing the location of graves G34, G35a and G35b, 1992. (Photo: Dabney, T.)



PLATE 2: Field photograph of grave G34.022, 1990. (Photo: Dabney, T.)



PLATE 3: Field photograph of grave G35a.018, 1992. (Photo: Dabney, T.)



PLATE 4: Field photograph of grave G35b.003, 1992. (Photo: Dabney, T.)



PLATE 5: Field photograph of grave F34 after removing capstones, exposing the soil beneath, 1992. (Photo: Dabney, T.)

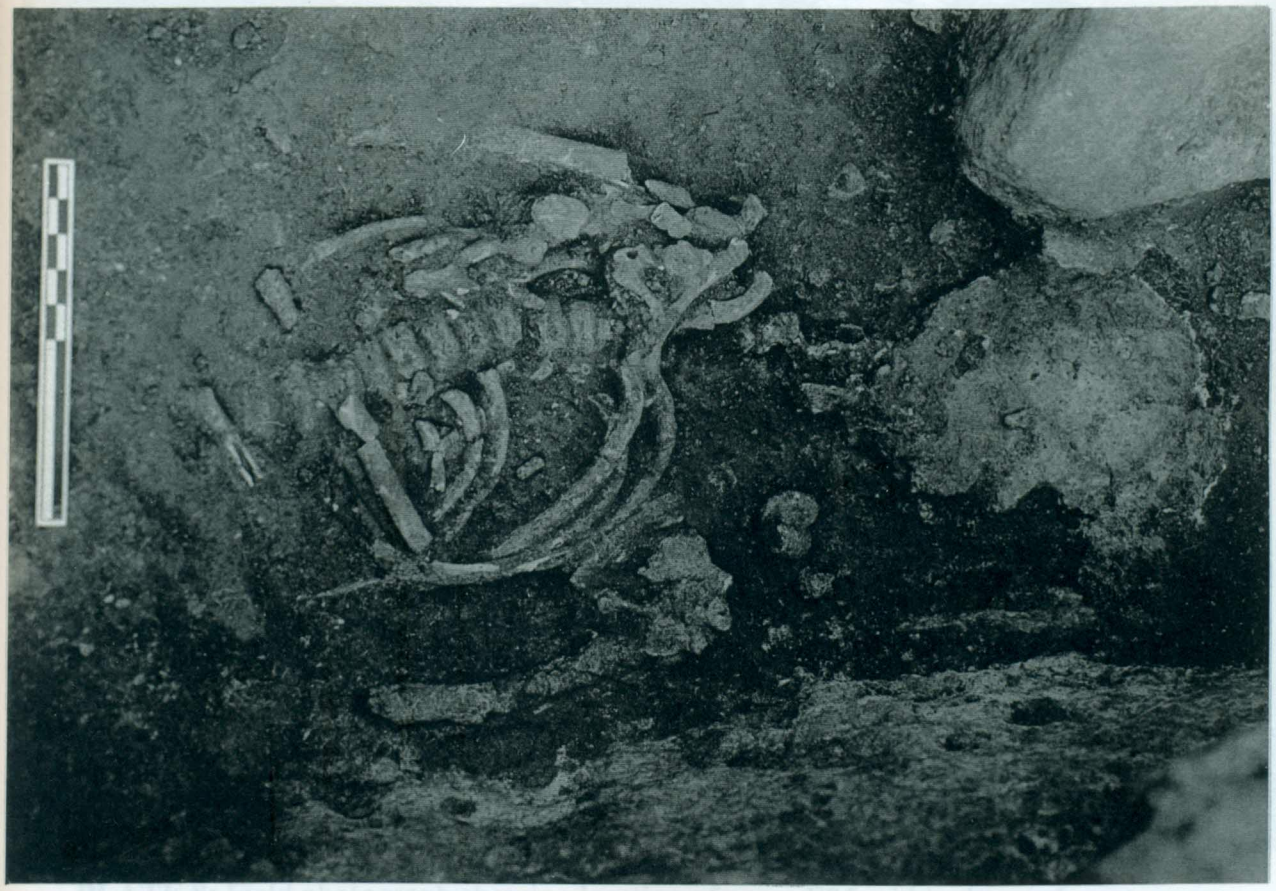


PLATE 6: Field photograph of grave F34.026 (infant), 1992. (Photo: Dabney, T.)



PLATE 7: Field photograph of grave F34.026 showing both individuals' burial position. The Subadult on the left and infant on the right, 1992. (Photo: Dabney, T.)



PLATE 8: Field photograph showing location of grave E35 within the north-east wall, 1990. (Photo: Dabney, T.)



PLATE 9: Field photograph of grave E35.022 showing the storage bin, 1990. (Photo: Dabney, T.)



PLATE 11: Field photograph of grave E36a.026, 1990. (Photo: Dabney, T.)



PLATE 10: Field photograph of grave E35.022 in-situ, 1990. (Photo: Dabney, T.)



PLATE 12: Left tibia of subadult G35a.018A showing the compression factor.



PLATE 13: Calcite coating and cementation of three arm bones of subadults F34.026, left humerus, right ulna and right radius.



PLATE 14: Calcite coating covering the right mandibulary teeth of subadult F34.026.(Photo: Göttingen, Schultz)



PLATE 15: The right mandibulary teeth of subadult F34.026 after cleaning with dental scaler. The lingual side of the second molar has calculus grade I (Schultz 1988a).

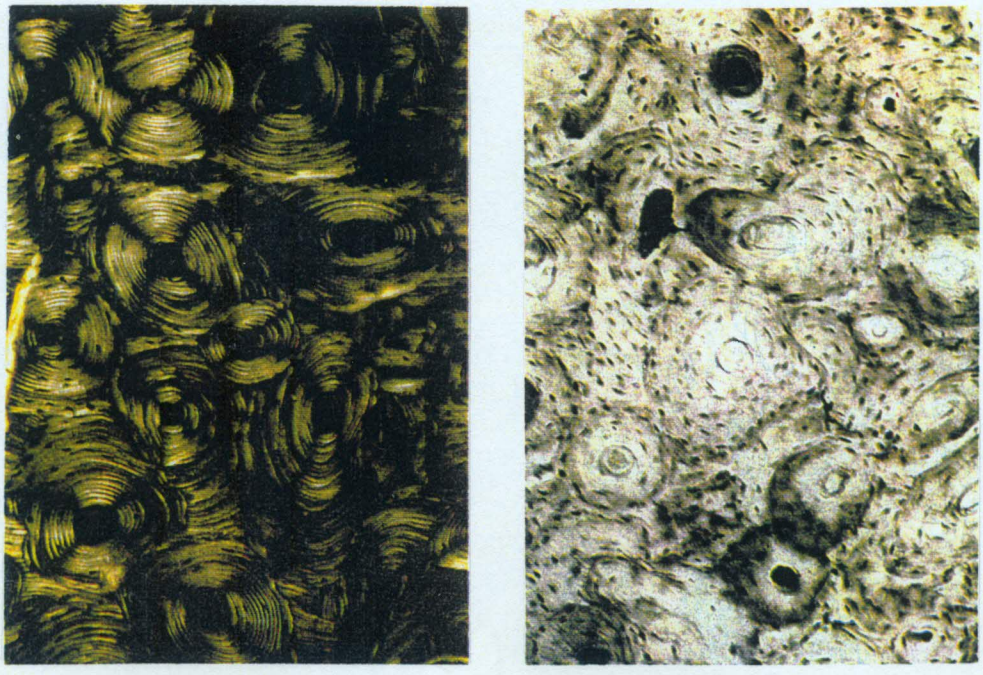


PLATE 16: Histological structure of cortical bone with the basic arrangement for preserved healthy bone.



PLATE 17: Subadult G35a.018B right mandible showing minimal amount of attrition, particularly on the premolars.



PLATE 18: Subadult F34.026 mandible exhibiting moderate dental wear.



PLATE 19: Anterior view of subadult F34.026 maxillae, showing the groove on the left central incisor occlusal surface.



PLATE 20: The maxillary incisors of subadult G35.018B showing the groove on both occlusal surfaces.

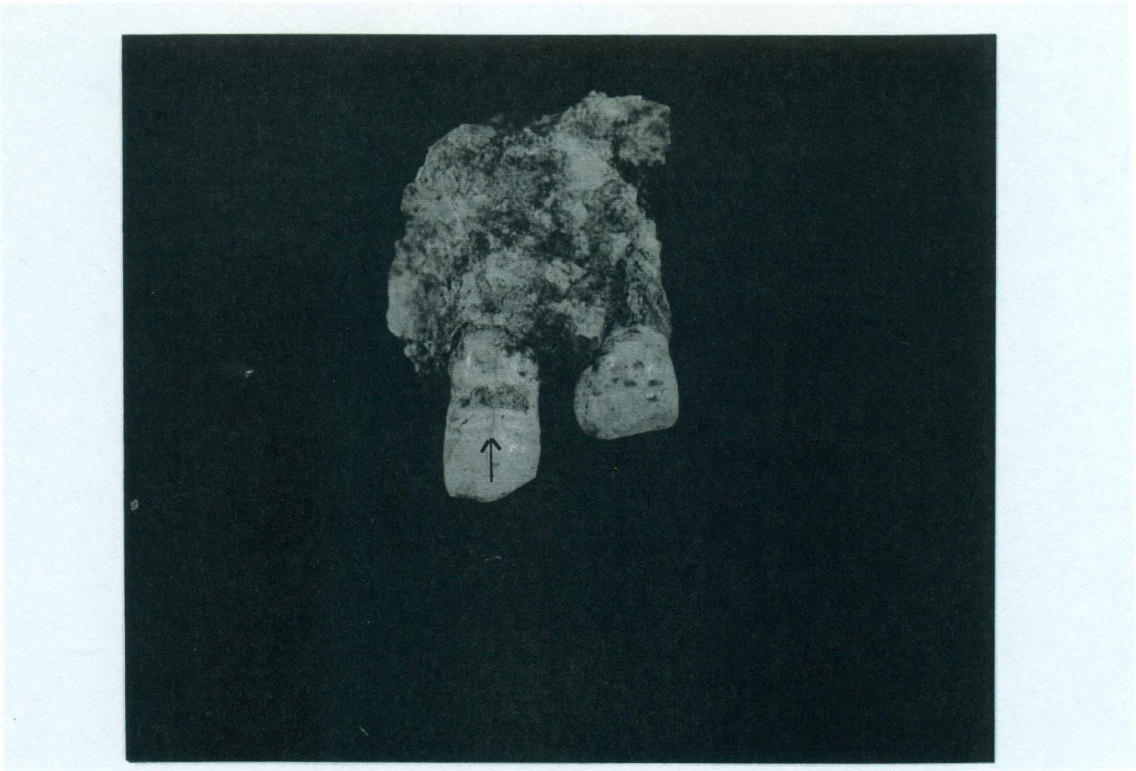


PLATE 21: Fragment of subadult G35a.018A, showing 6 hypoplasia grooves on the buccal side of the right mandibulary canine.

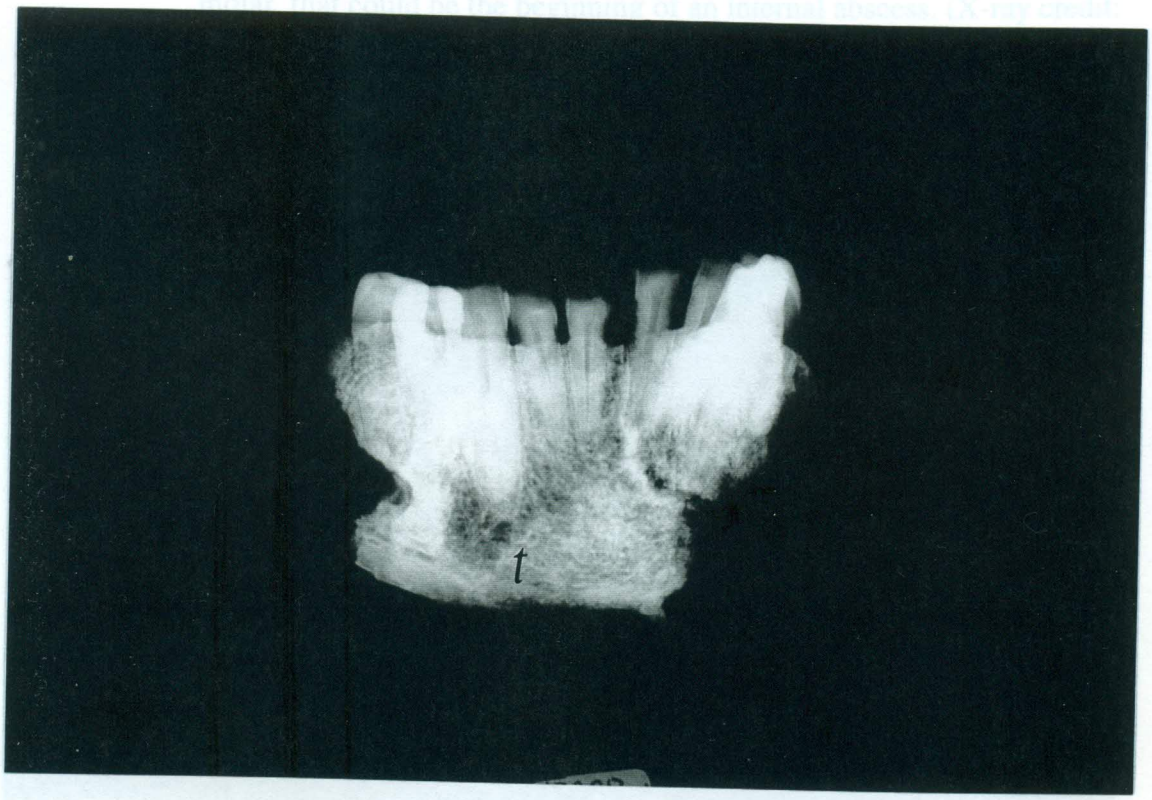


PLATE 22: Radiograph of subadult F34.026, anterior portion of the mandible showing an area of translucency under the right canine as a possible abscess.

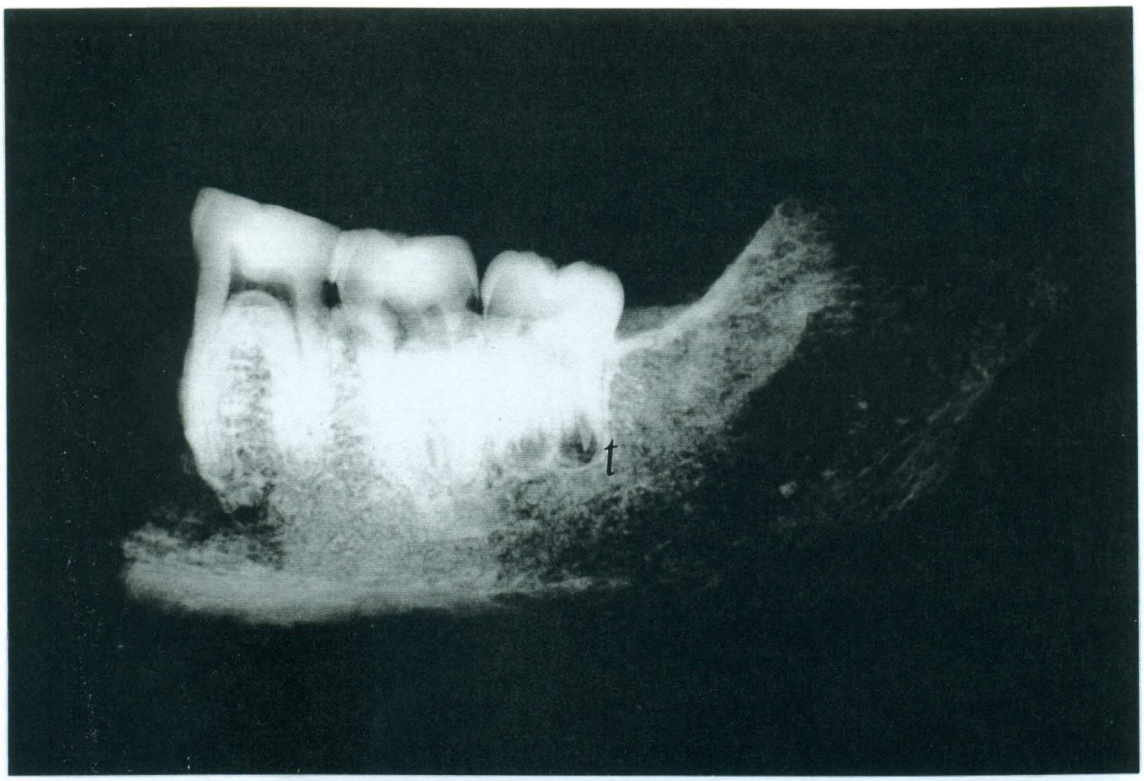


PLATE 23: Radiograph of subadult F34.026 right mandible with two small areas of translucency located inferior and around the roots of the right third molar, that could be the beginning of an internal abscess. (X-ray credit: Göttingen, Schultz)



PLATE 24: Subadult F34.026 mandible showing an internal V shape.

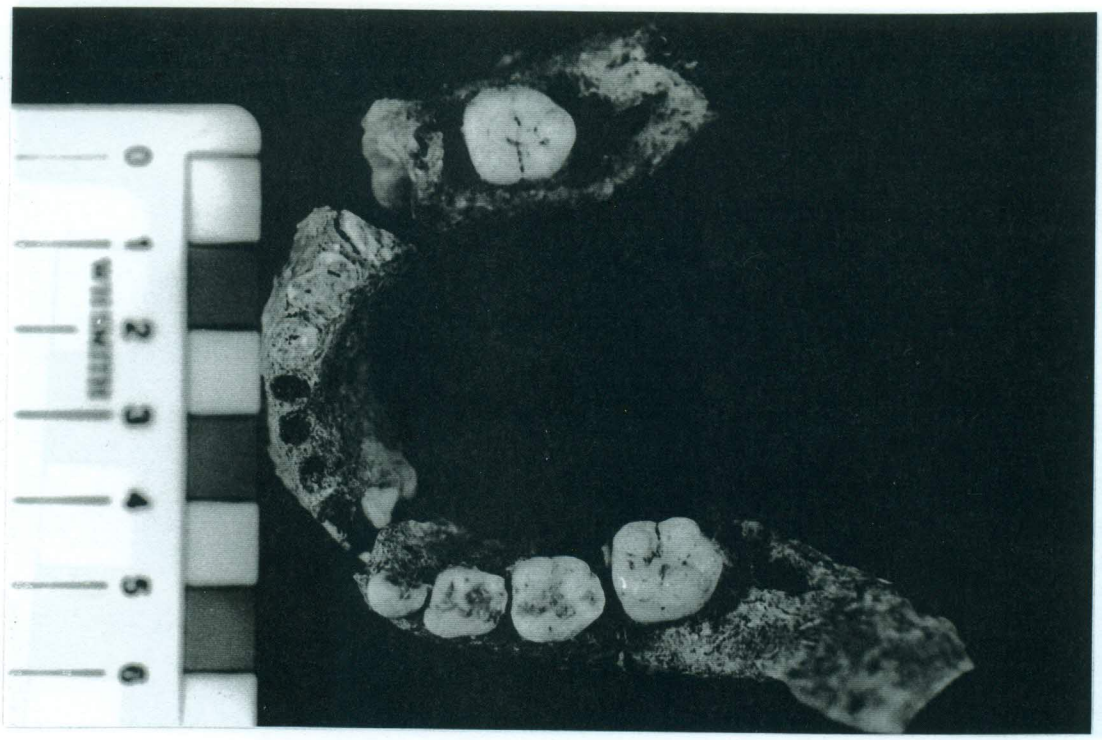


PLATE 25: Juvenile G34.022 showing normal internal curvature.



PLATE 26: Difference in mandible antero-posterior width between, top: juvenile G34.022 and bottom: Blackfriars juvenile #203.

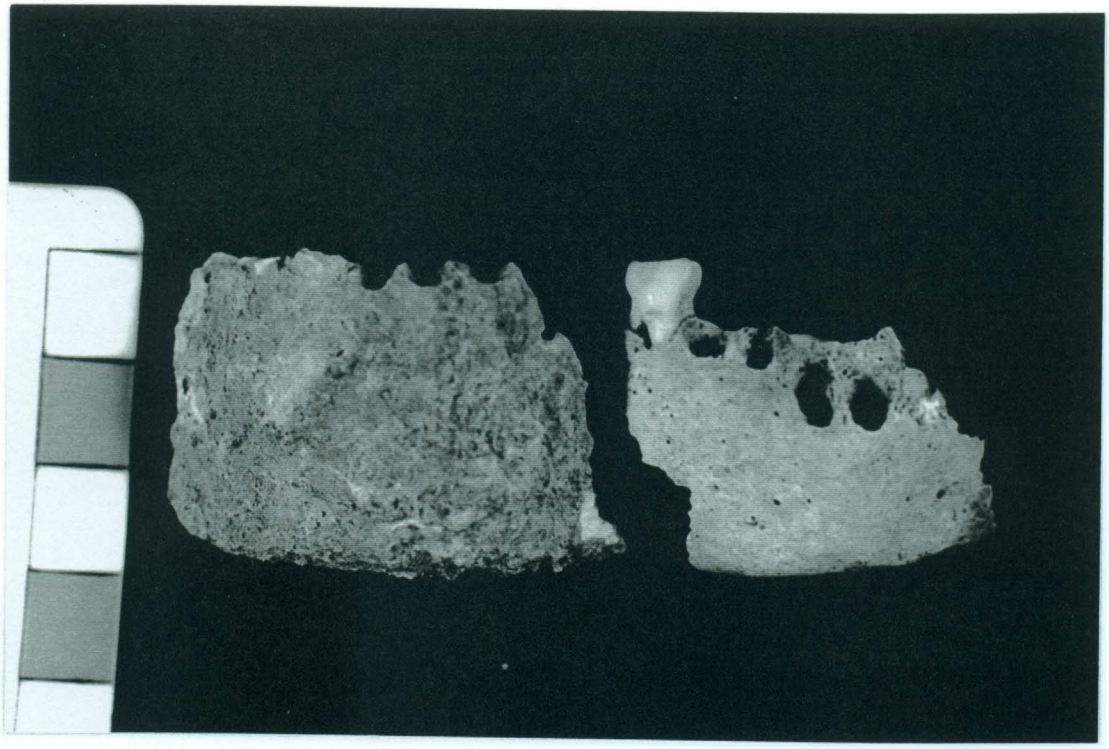


PLATE 27: Difference in mandible anterior side between, left: juvenile G34.022 and right: Blackfriars juvenile #203.



PLATE 28: Radiograph of juvenile E35.022 left mandible with congenital absence of the second premolar.

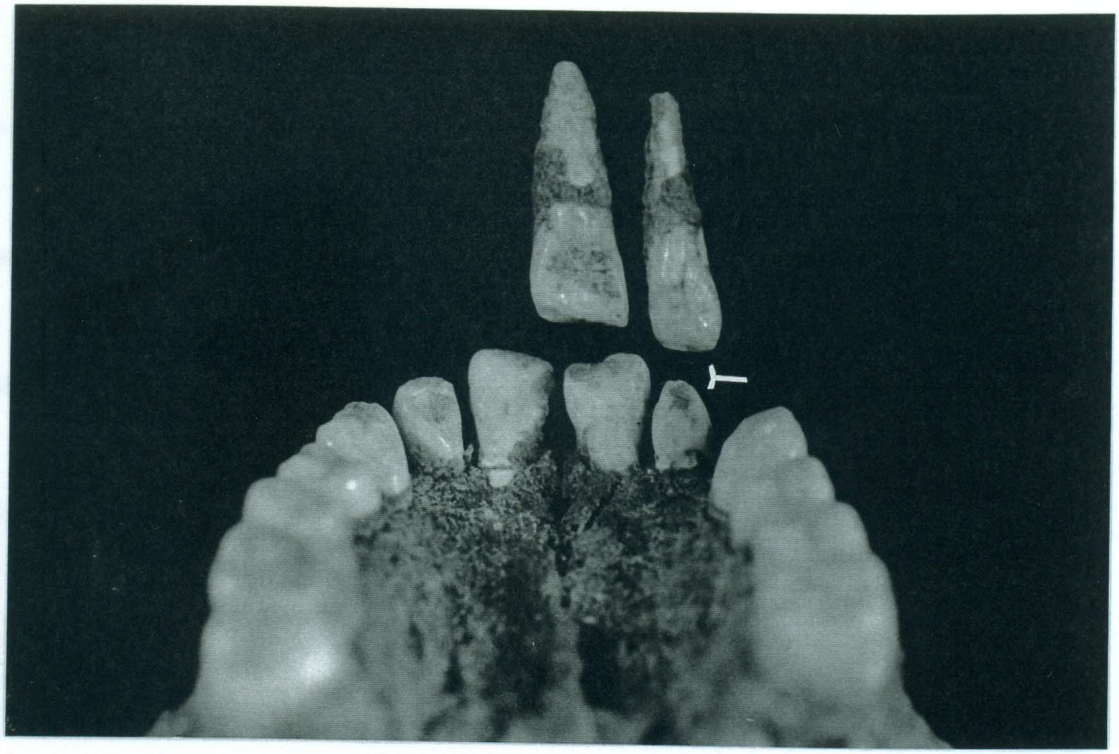


PLATE 29: The Asian genetic trait shovel-shape on the lateral maxillary incisors in the two subadults, top: G35a.018A and bottom: F34.026.



PLATE 30: Subadult F34.026 with rotation of the left lateral maxillary incisors to the mesio-lingual side bringing the tooth closer to the distal side of the left central incisor.

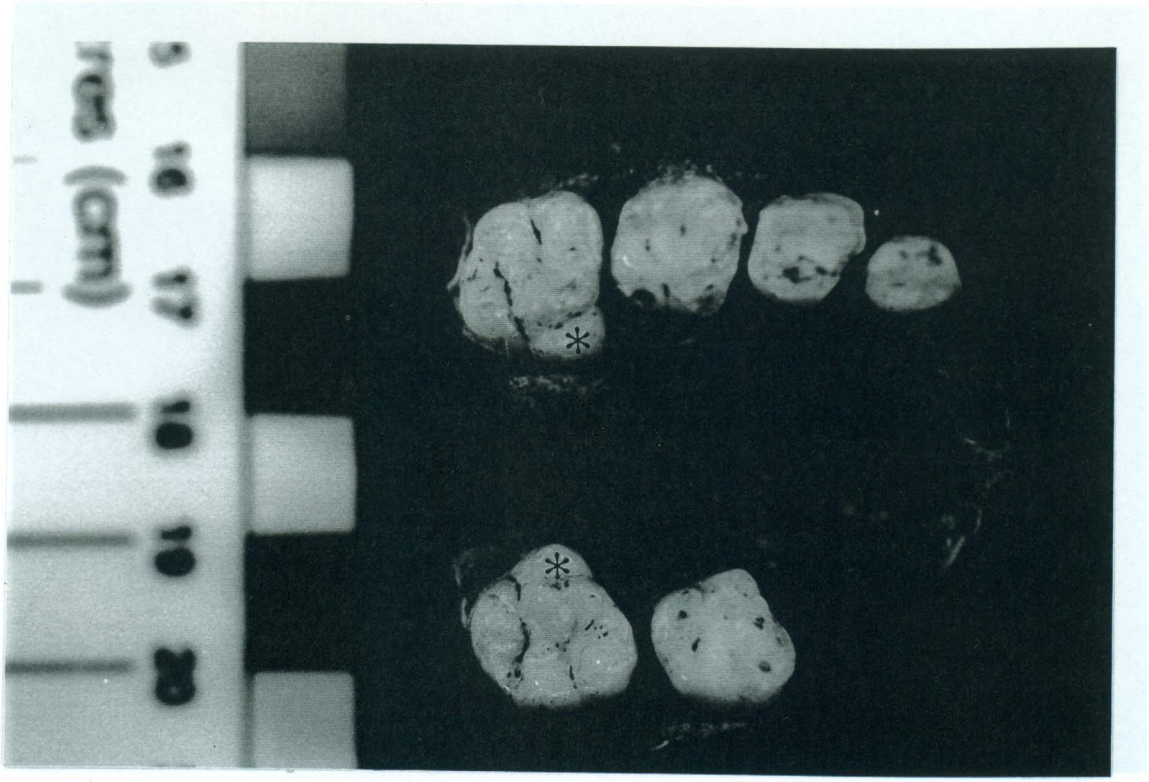


PLATE 31: The genetic trait of Carabelli cusp on both side of the permanent maxillary first molars in the dentition of juvenile G34.022.



PLATE 32: Subadult F34.026's tibiae and fibula diaphyses showing porosity with thickening of the endosteal surfaces.

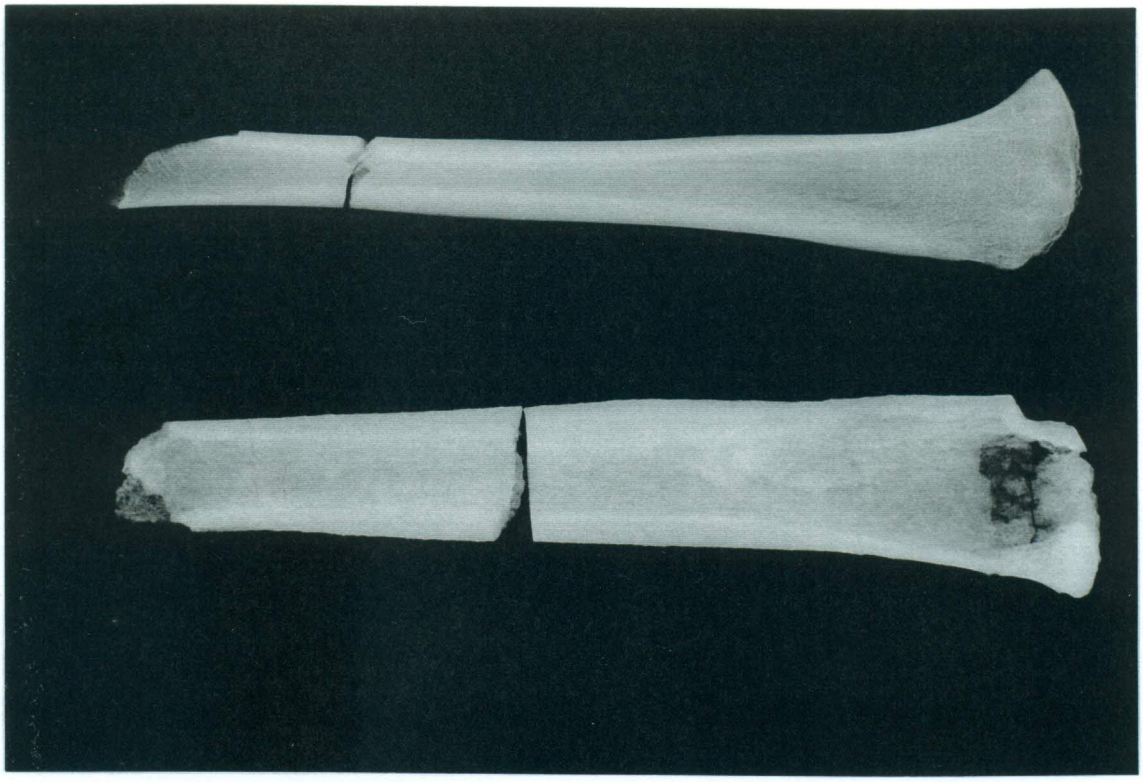


PLATE 33: Radiograph showing change in contour shape and thickening of subadult F34.026's left tibia (bottom), and (top) is Blackfriars subadult #89.

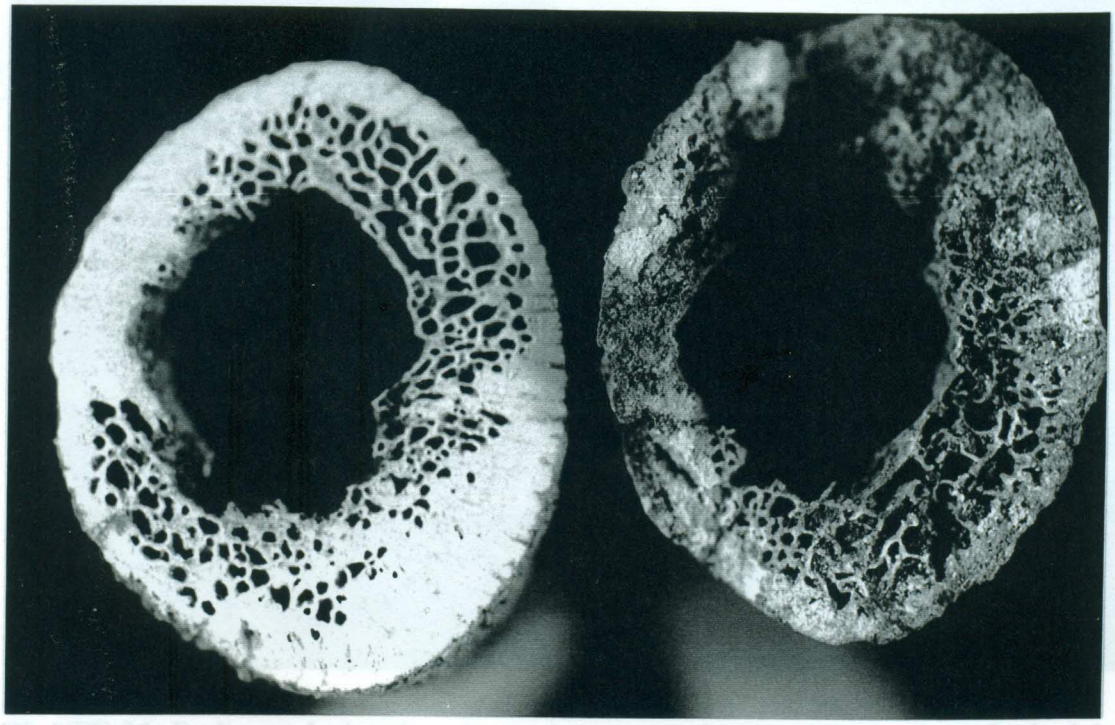


PLATE 34: Mid-section of subadult F34.026 left tibia showing endosteal porosity and enlargement of the diaphysis.

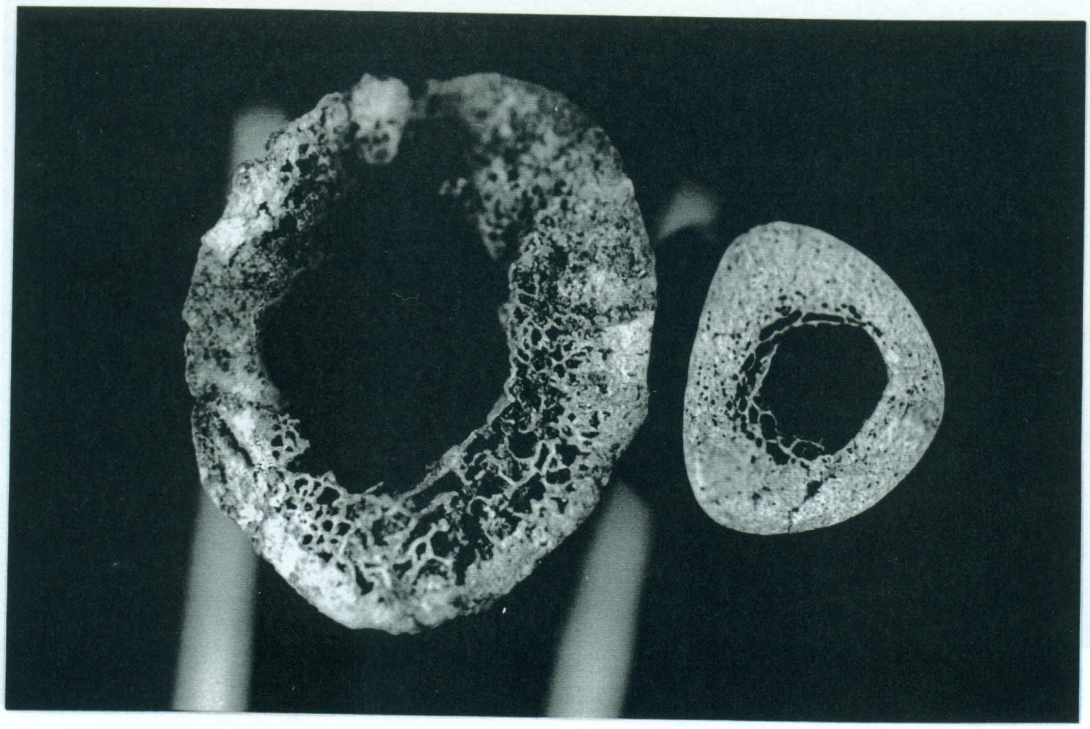


PLATE 35: Mid-section of subadult F34.026's left tibia (left), compared to Blackfriars subadult #89 mid-section tibia, notice the large difference in size between the two.

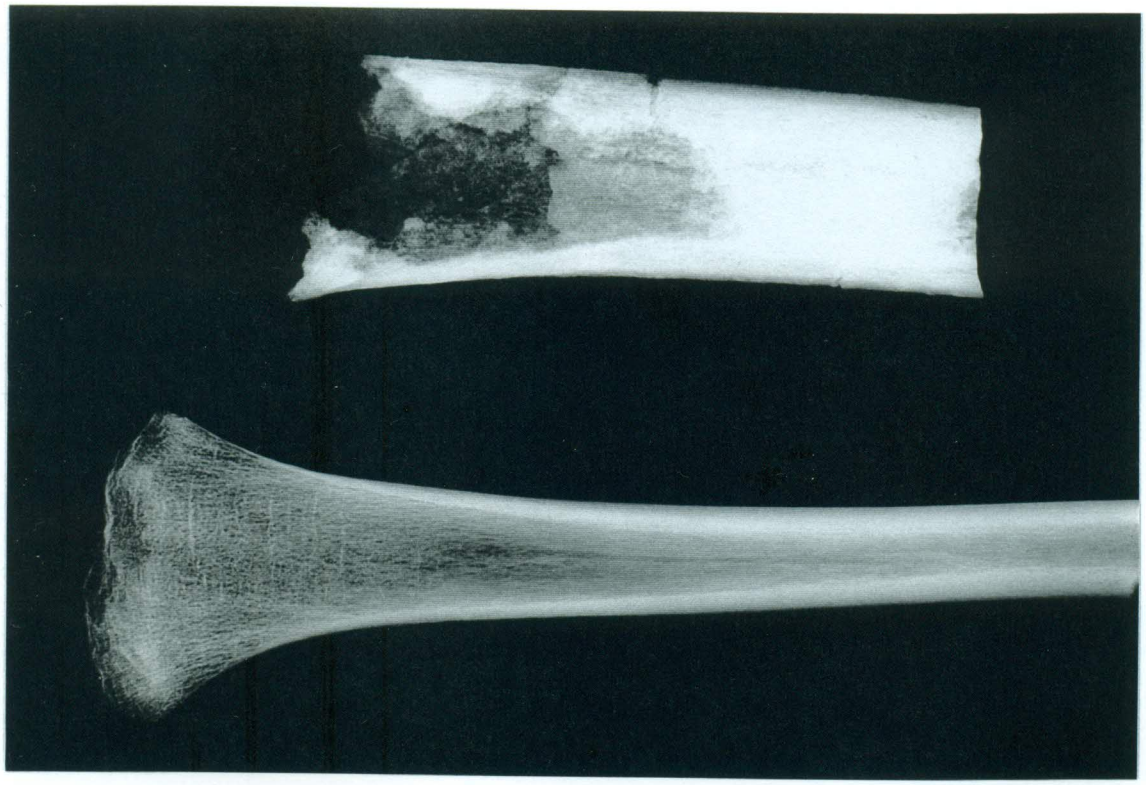


PLATE 36: Radiograph showing change in contour shape and thickening of subadult F34.026 right tibia (right side), and the left side is Blackfriars subadult #89.



PLATE 37: Subadult F34.026's tibiae compared to the (middle) Blackfriars subadult #89 tibia.

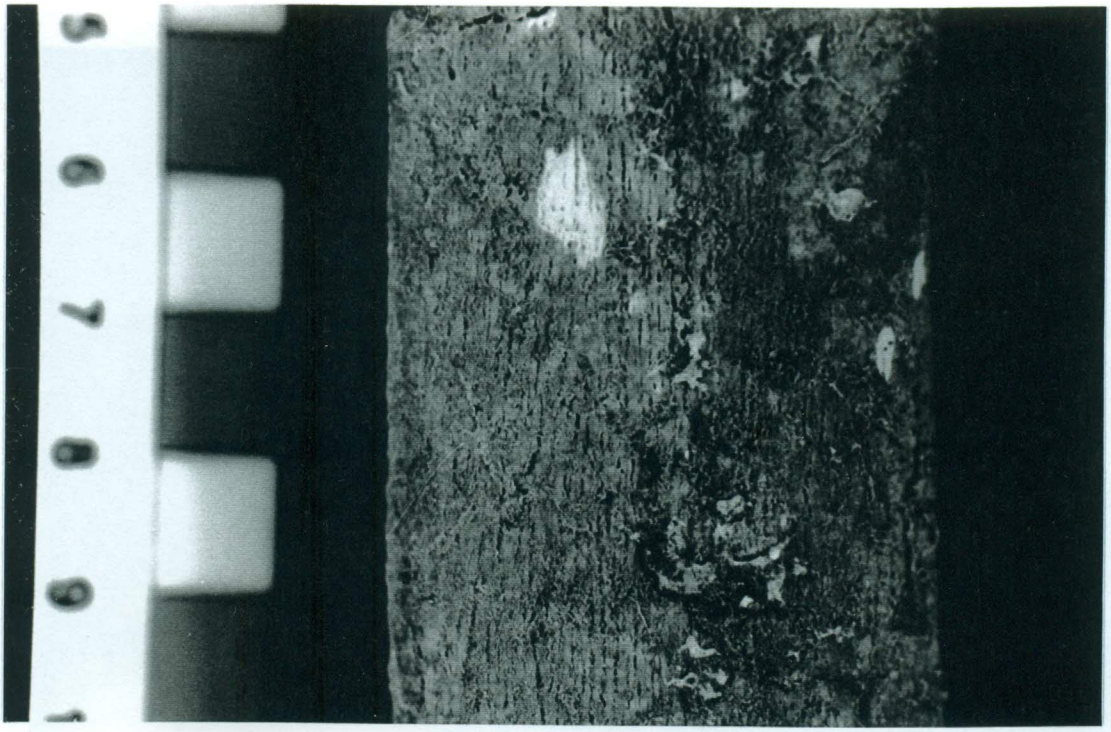


PLATE 38: Subadult F34.026's right tibia's shaft had little calcite encrustation covering the outer cortical surface, thus exposing periosteal reaction in the form of striations.

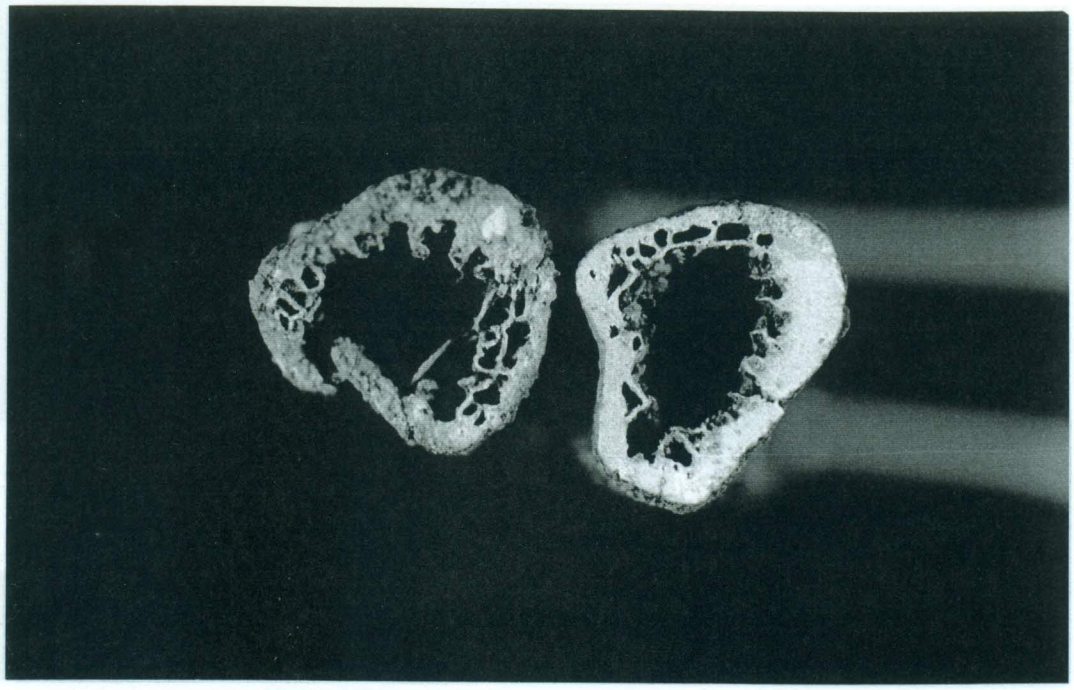


PLATE 39: Subadult F34.026's right fibula where the cortical bone became thinner due to the extensive porosity that had taken a large part of the inner surface of the diaphysis.

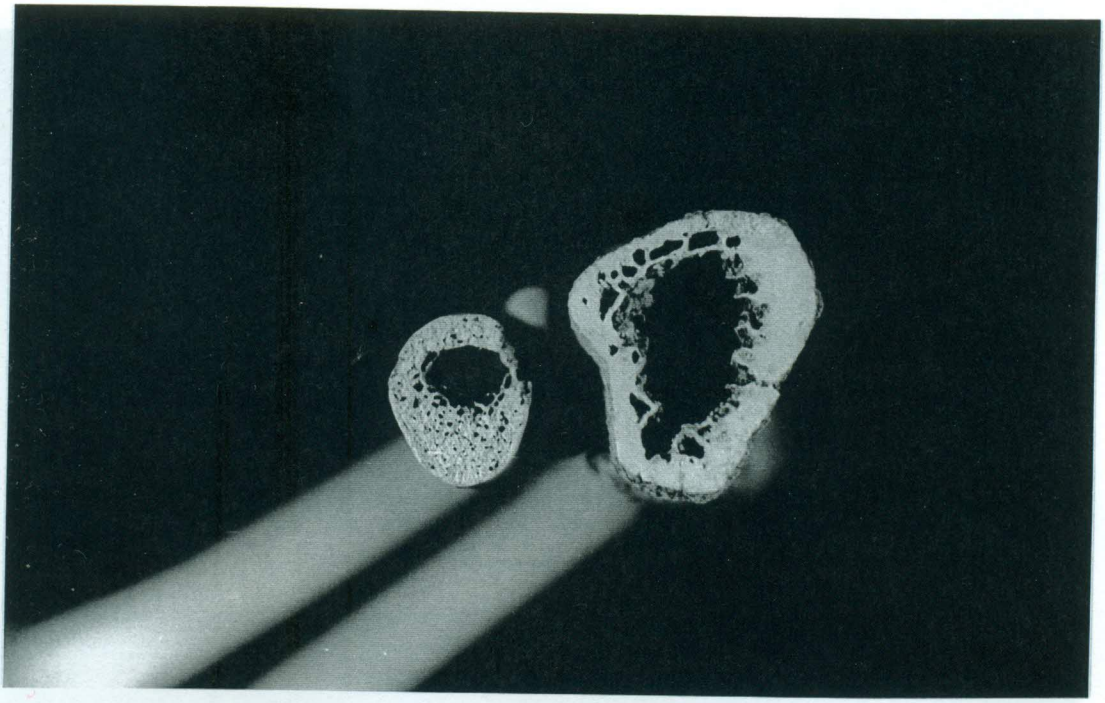


PLATE 40: Subadult F34.026's right fibula where the porosity had expanded and enlarged the diaphysis when compared to the Blackfriars subadult #89 (on the right).



PLATE 41: Subadult F34.026's right fibula where porosity had changed the normal contour of the fibula and replaced by a rounded contour, as compared to the Blackfriars subadult #89 (on the left).



PLATE 42: Subadult F34.026's left femur diaphysis with slight thickening of the cortical bone as compared to the Blackfriars subadult #89 (on the left).

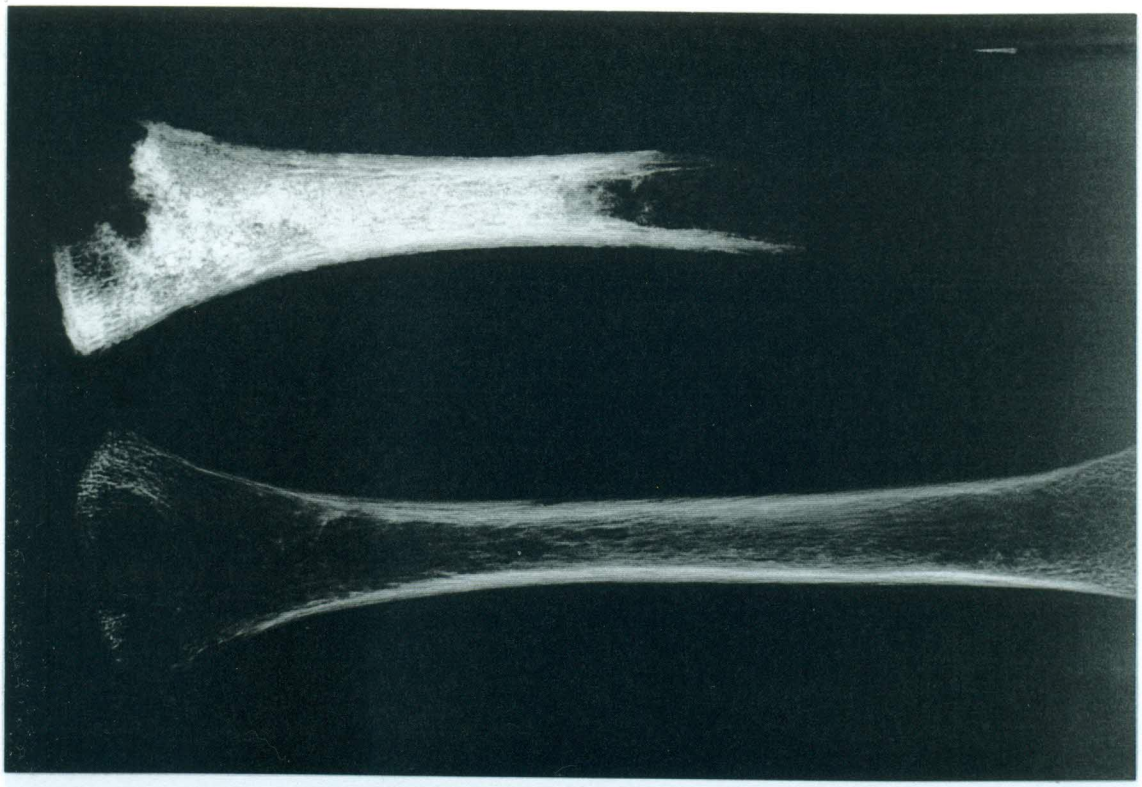


PLATE 43: Infant F34.026's right humerus had slight cortical thickening when compared to the infant from the British cemetery Holton LeClay Church #B42 (bottom).

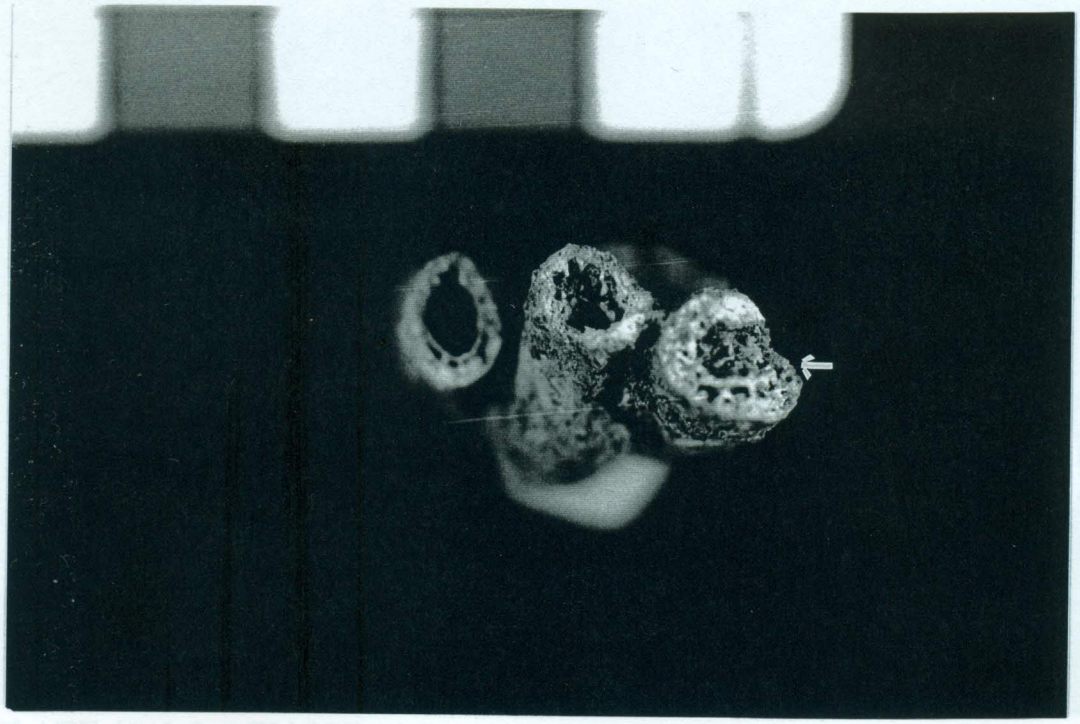


PLATE 44: Infant F34.026's right humerus had porosity of the endosteal side of the shaft in the form of one circular line (the left bone), (centre) radius and (left) ulna.

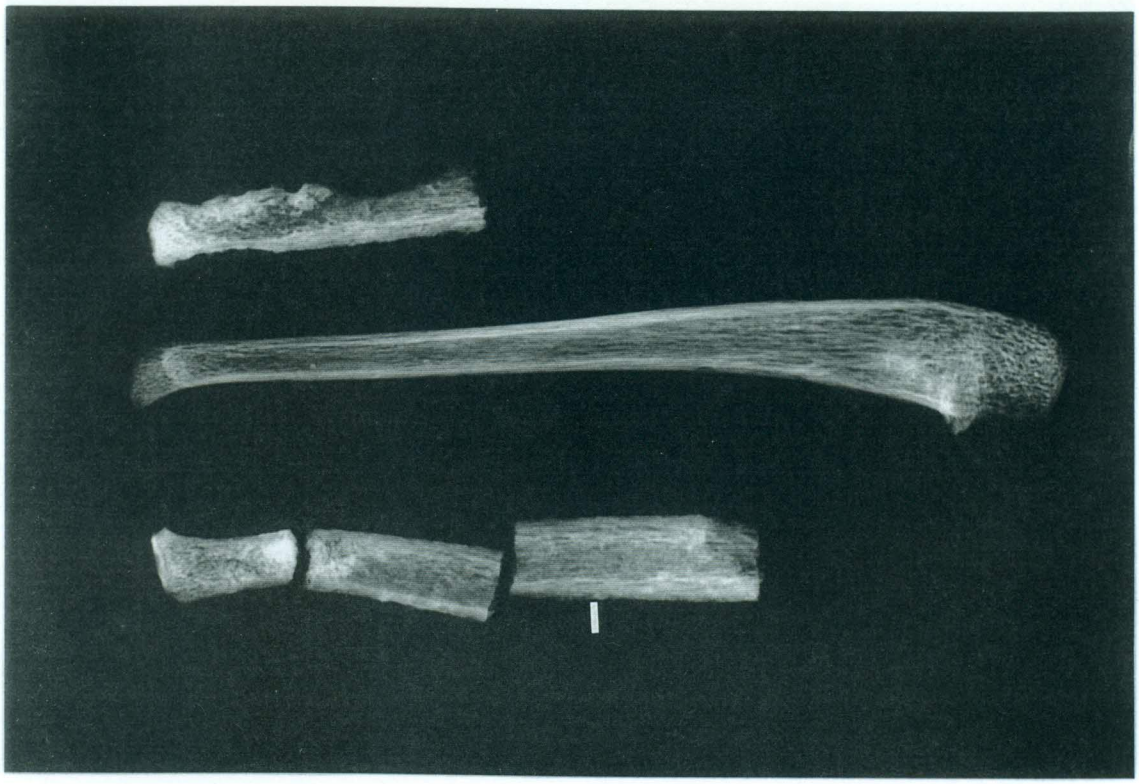


PLATE 45: Infant F34.026's ulnae diaphyses with porosity of endosteal side contributing to the cortical thickness. (Centre) is infant #B42 from the British cemetery Holton LeClay Church

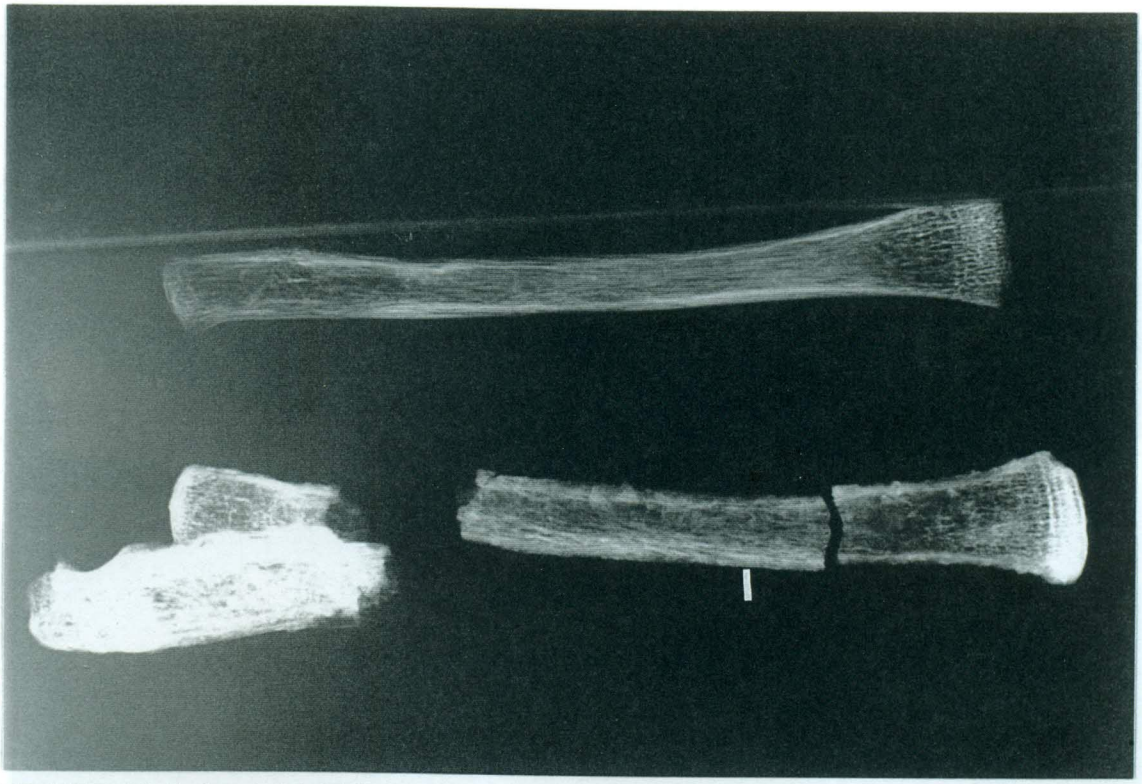


PLATE 46: Infant F34.026's right radius with porosity of the endosteal side that had contributed to the cortical thickness of the diaphysis. Thickening is concentration in the middle and proximal part of the shaft. (Bottom) is British cemetery Holton LeClay Church #B42 infant.

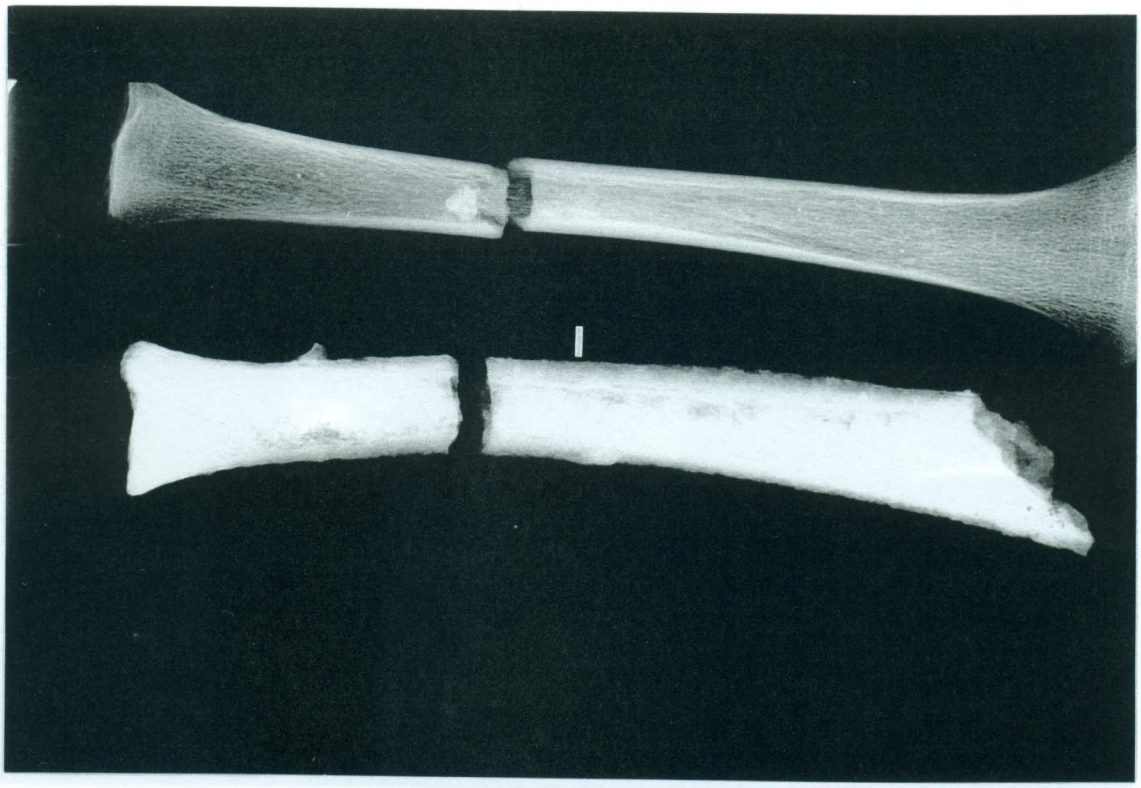


PLATE 47: Juvenile E35.022's left tibial diaphysis (bottom), showing cortical thickness and porosity.

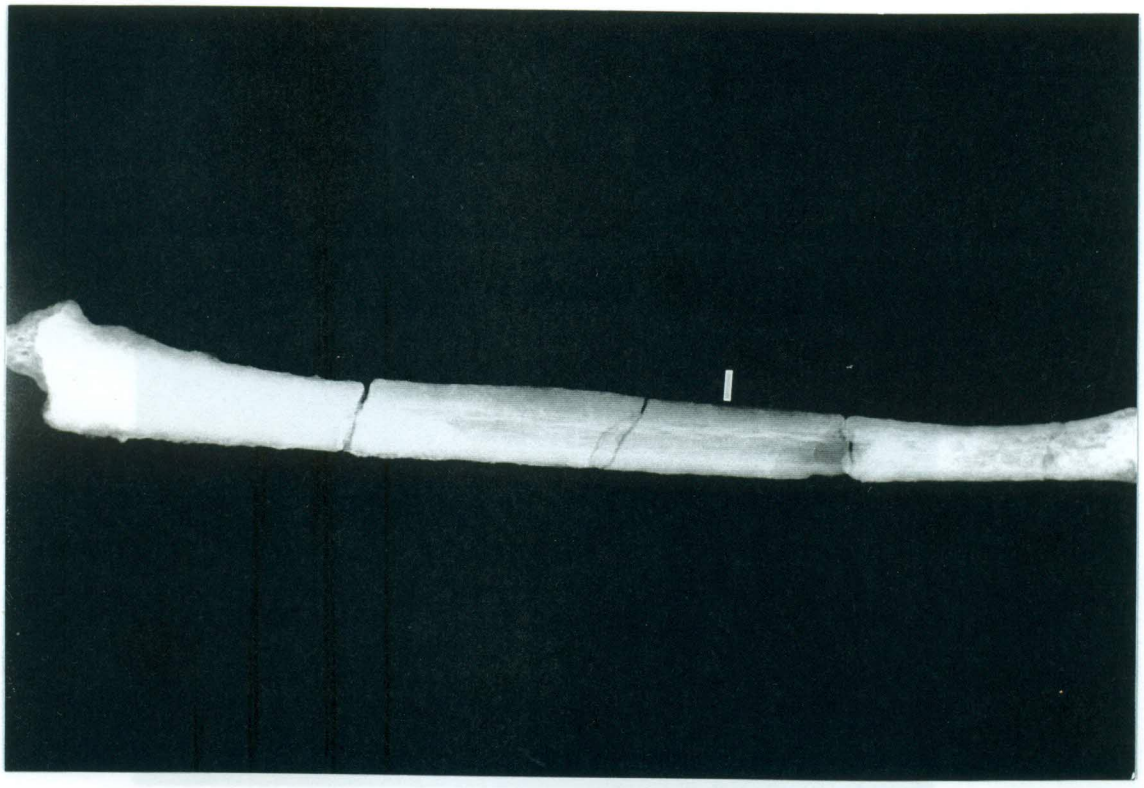


PLATE 48: Juvenile E35.022's left ulna diaphysis, showing cortical thickness and porosity.

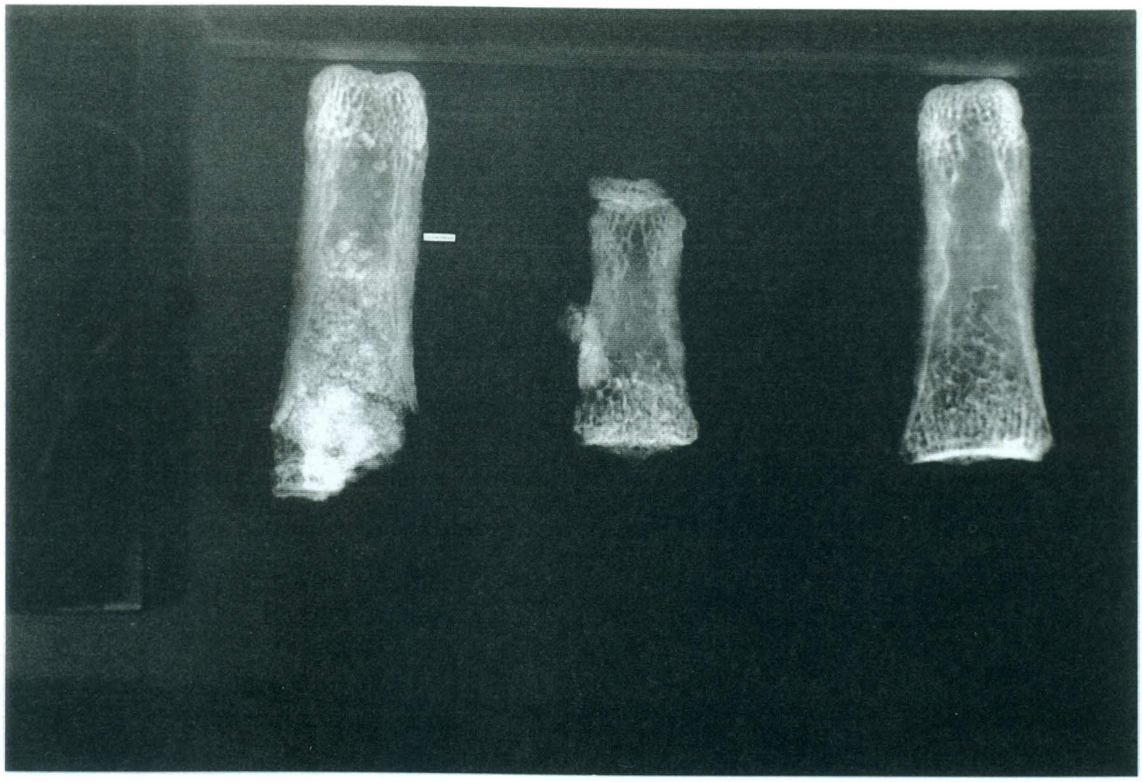


PLATE 49: Subadult F34.026's hand phalanges with endosteal porosity along the shafts.

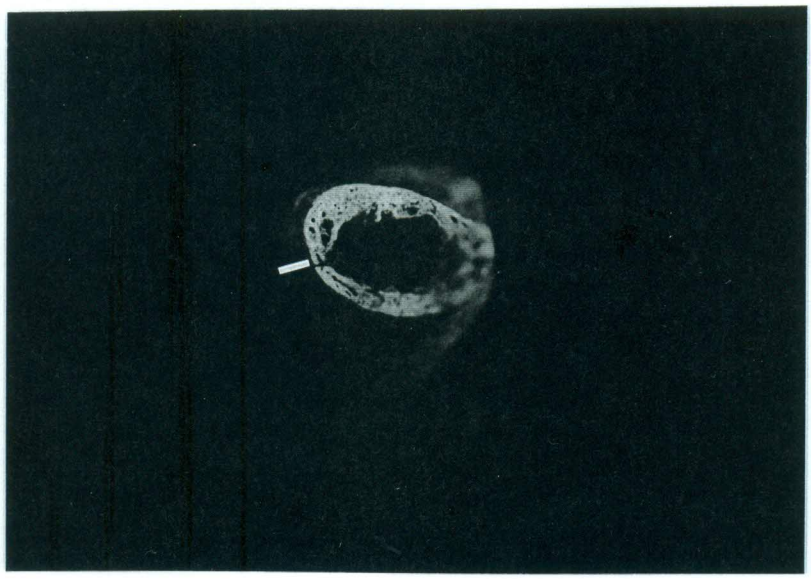


PLATE 50: Either subadult G35a.018A or B's right fifth metatarsal, showing endosteal porosity along the shaft, as one circular line.

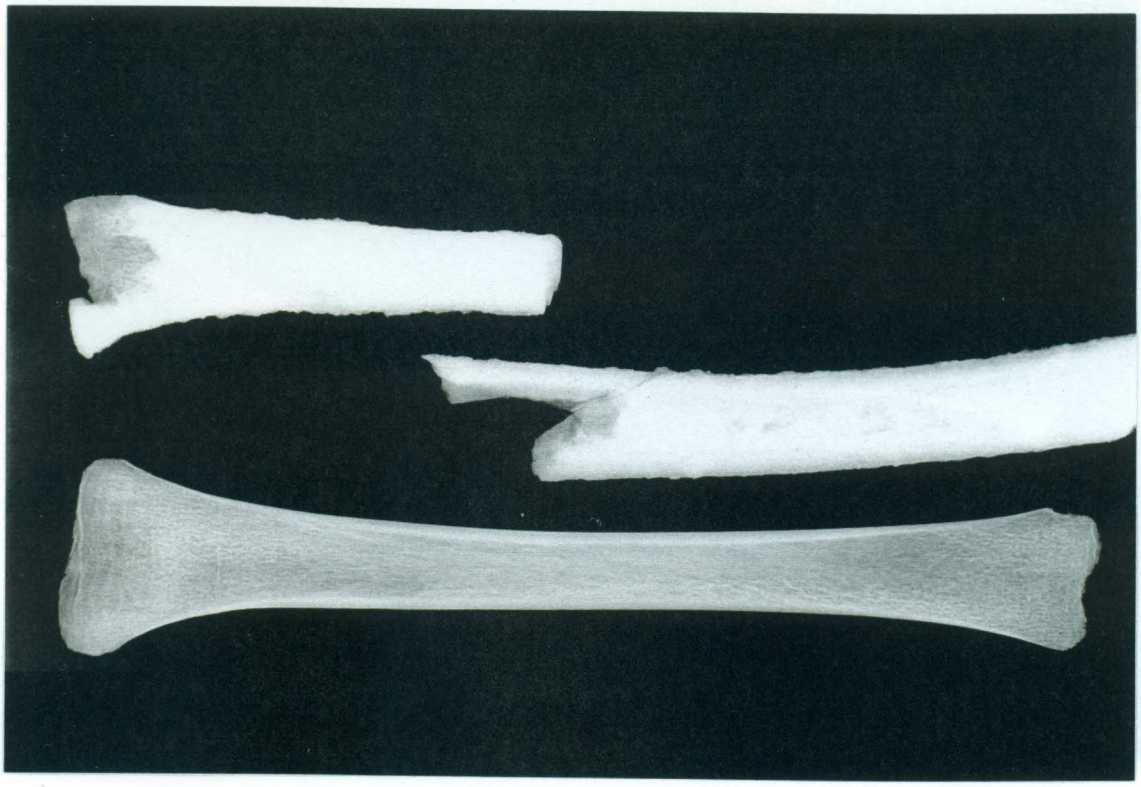


PLATE 51: Juvenile G34.022's right tibial diaphysis exhibiting 'the normal' cortical thickness.

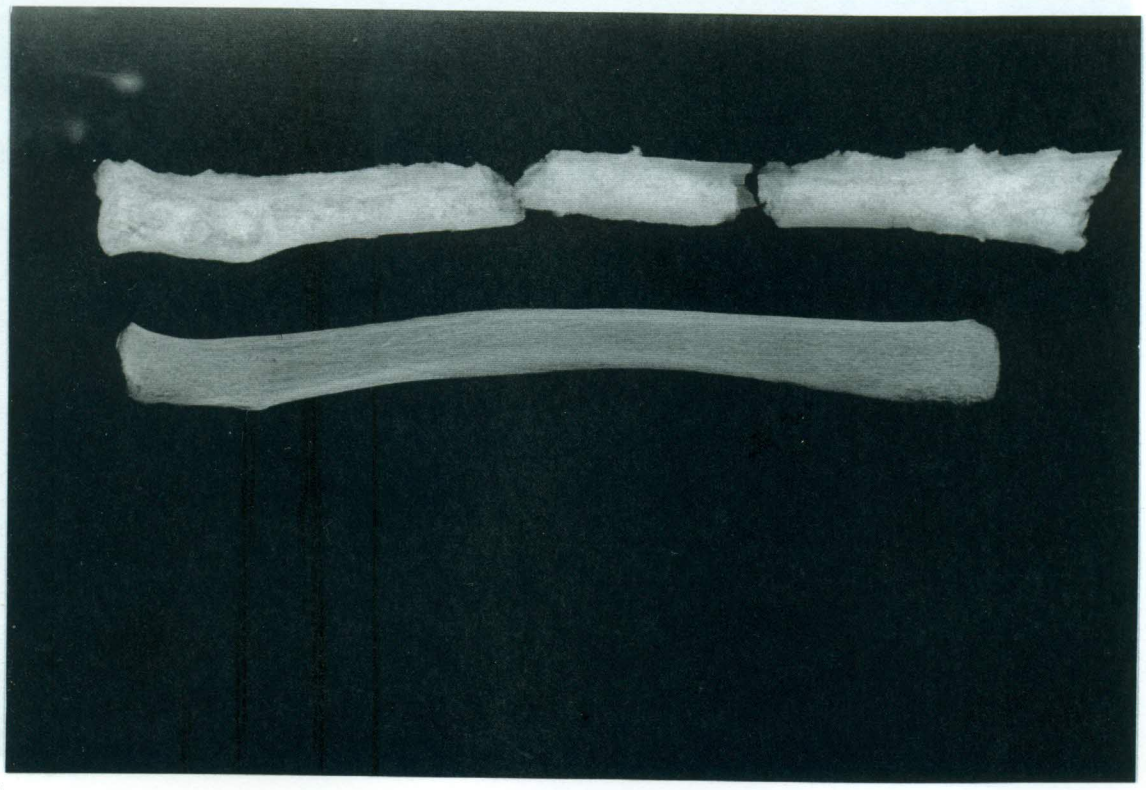


PLATE 52: Juvenile G34.022's right radial diaphysis with 'the normal' cortical thickness.

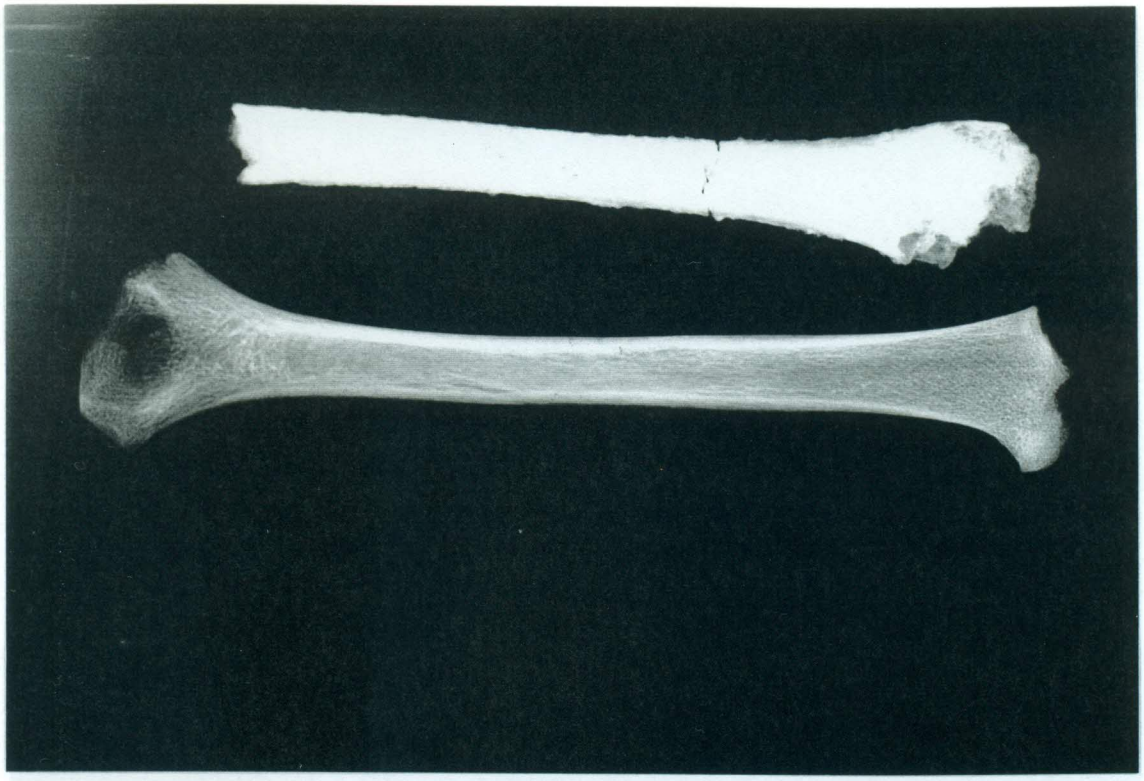


PLATE 53: Juvenile E35.022's left humeral diaphysis with 'the normal' cortical thickness.

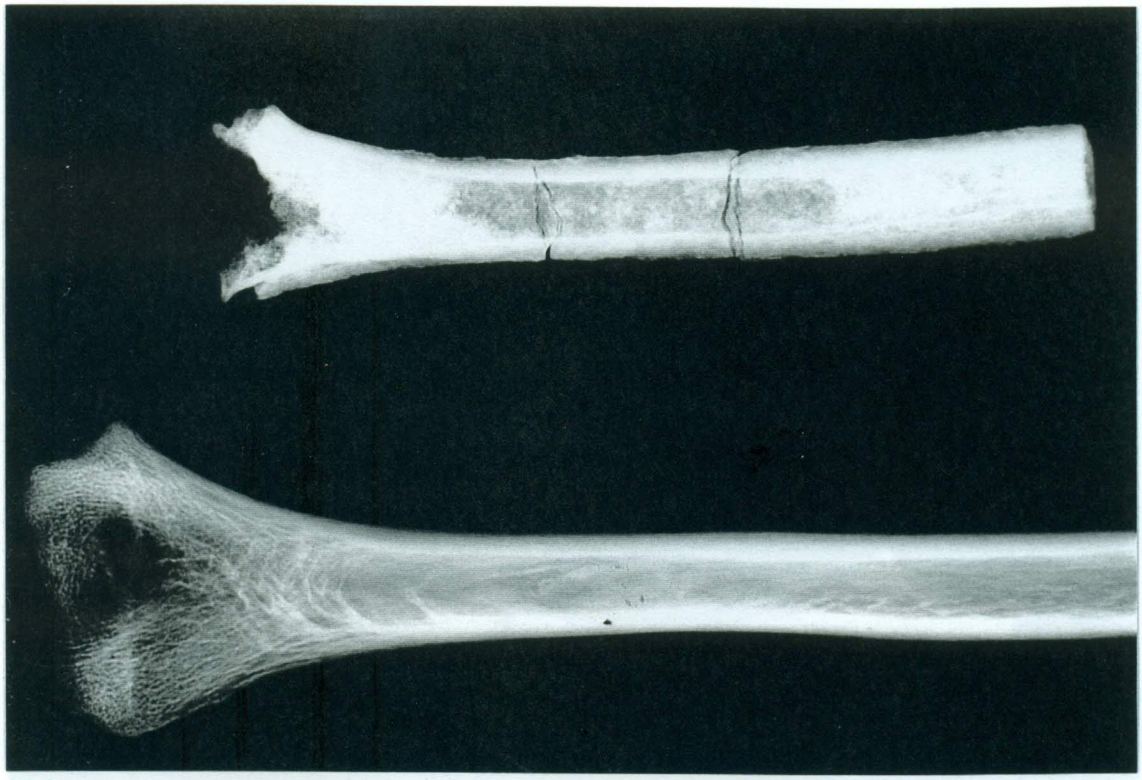


PLATE 54: Juvenile E35.022's right humeral diaphysis with 'the normal' cortical thickness.



PLATE 55: Juvenile E35.022's right and left radii diaphyses with 'the normal' cortical thickness.

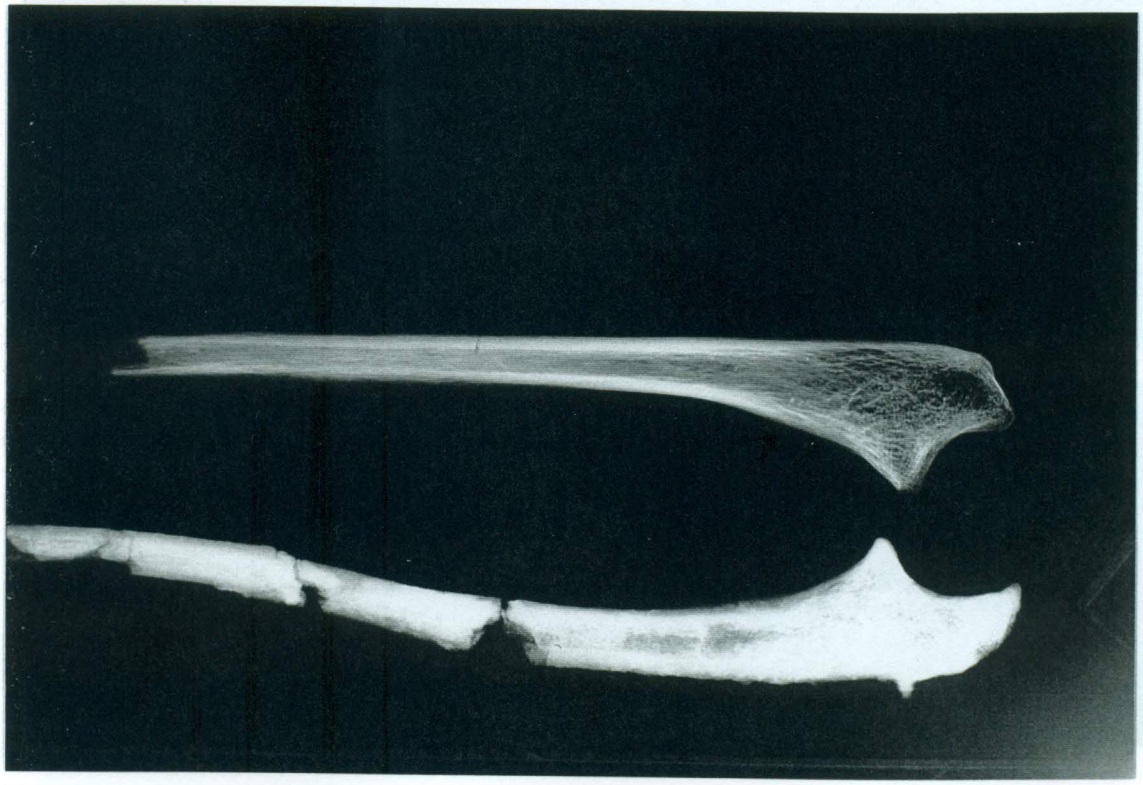


PLATE 56: Juvenile E35.022's right ulna diaphysis (bottom) with 'the normal' cortical thickness.

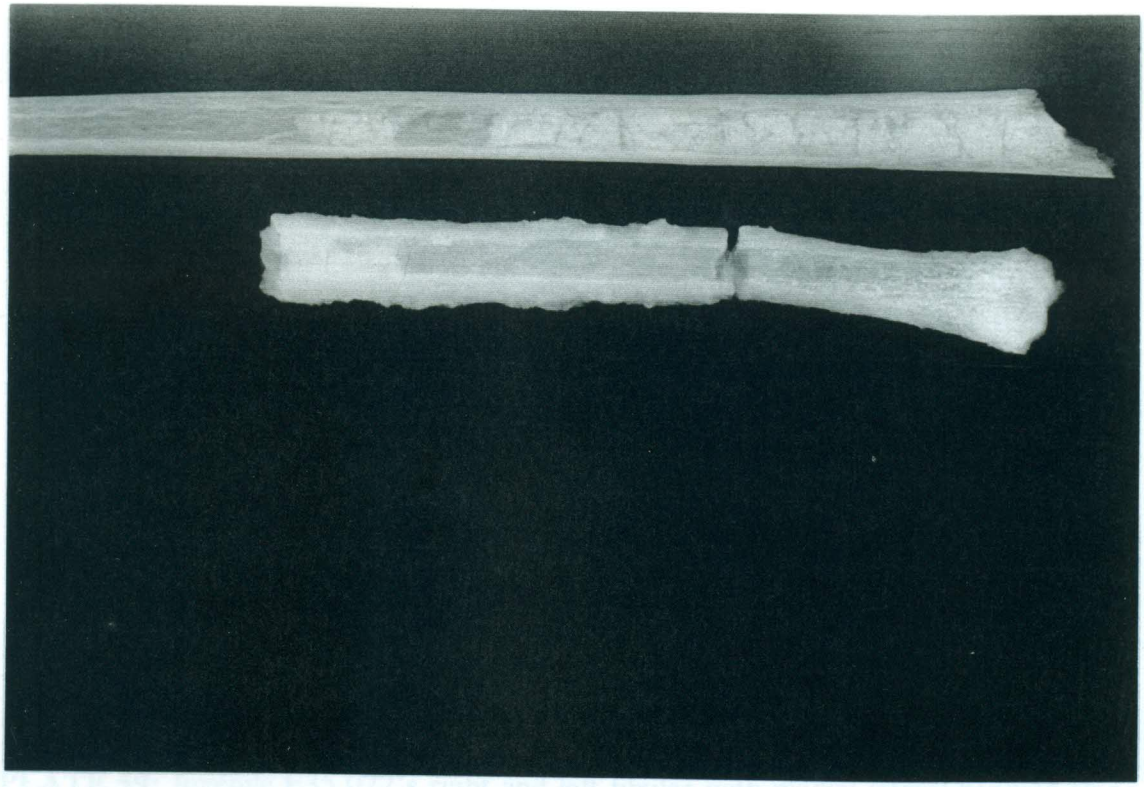


PLATE 57: Juvenile G35b.003's right fibula diaphysis (bottom) with 'the normal' cortical thickness.

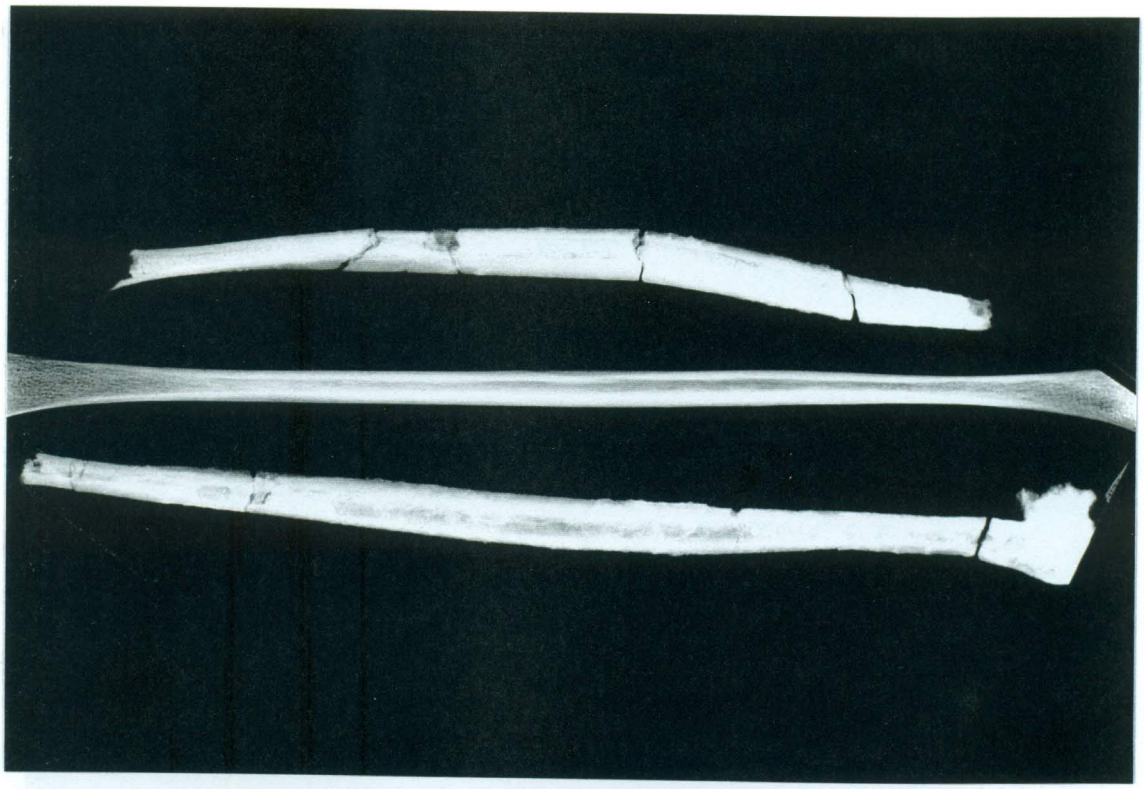


PLATE 58: Juvenile E35.022's right and left fibulae with medial-lateral bending along the shafts and bone thickening at the medial sides, where the left fibula had less cortical thickening.



PLATE 59: Juvenile E35.022's right and left fibulae with medial-lateral bending along the shafts.



PLATE 60: Subadult F34.026's right fibula with medial-lateral bending.

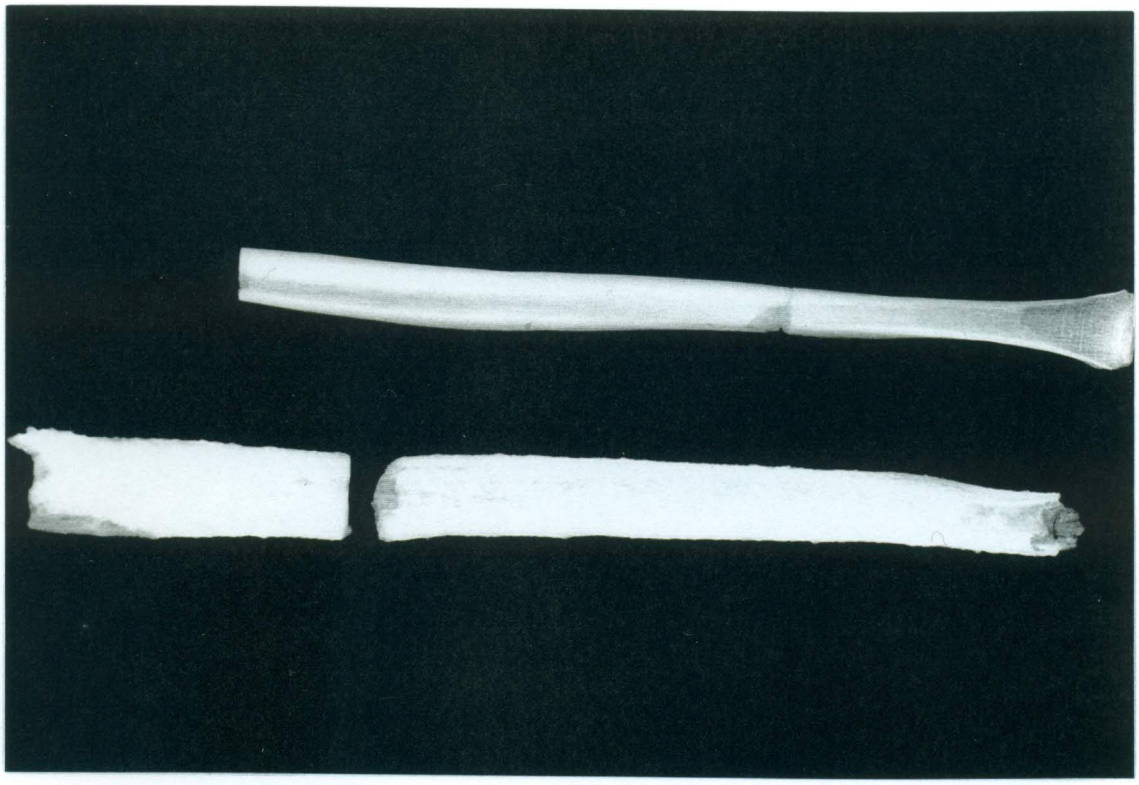


PLATE 61: Subadult F34.026's right fibula that do not have cortical thickness that usually accompanies Rickets.

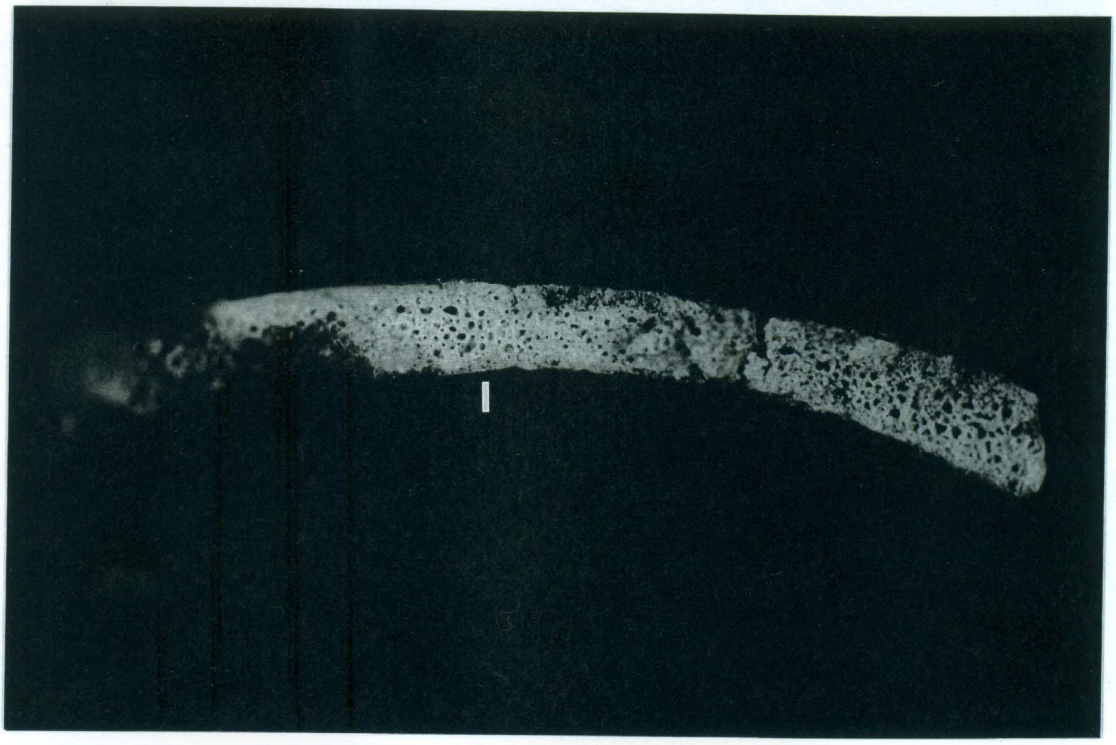


PLATE 62: Subadult F34.026's frontal fragment with diploë expansion.

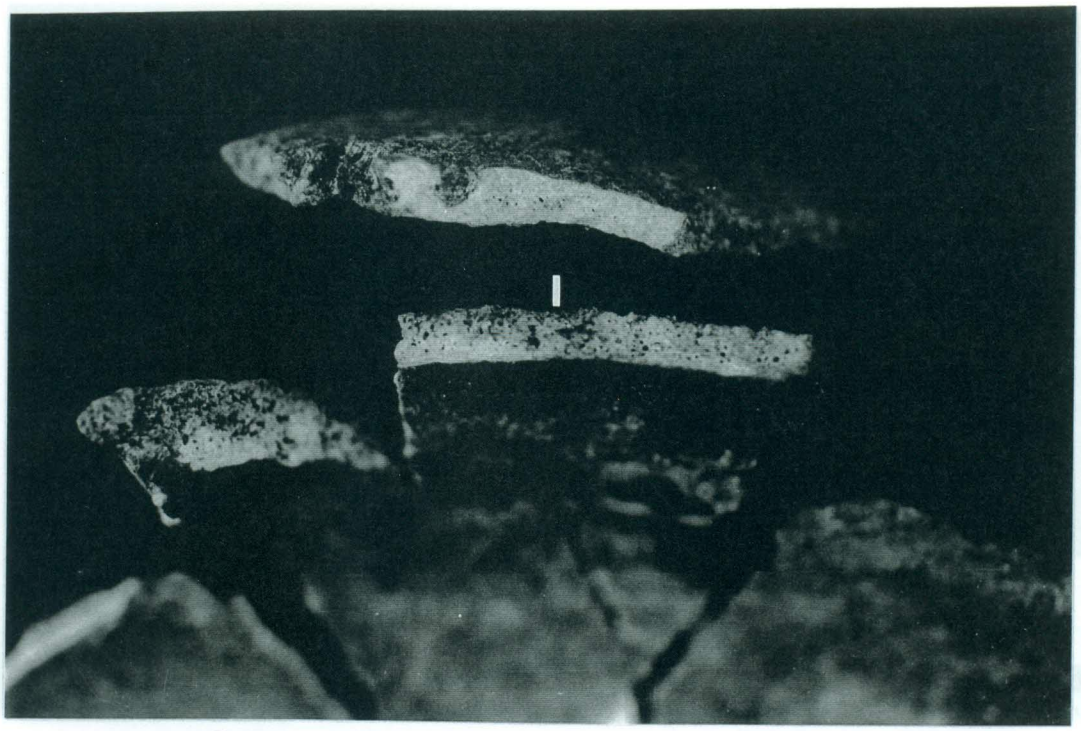


PLATE **63**: Subadult F34.026's parietal section with diploë expansion (bottom), compared to E35.022's parietal bone (top).

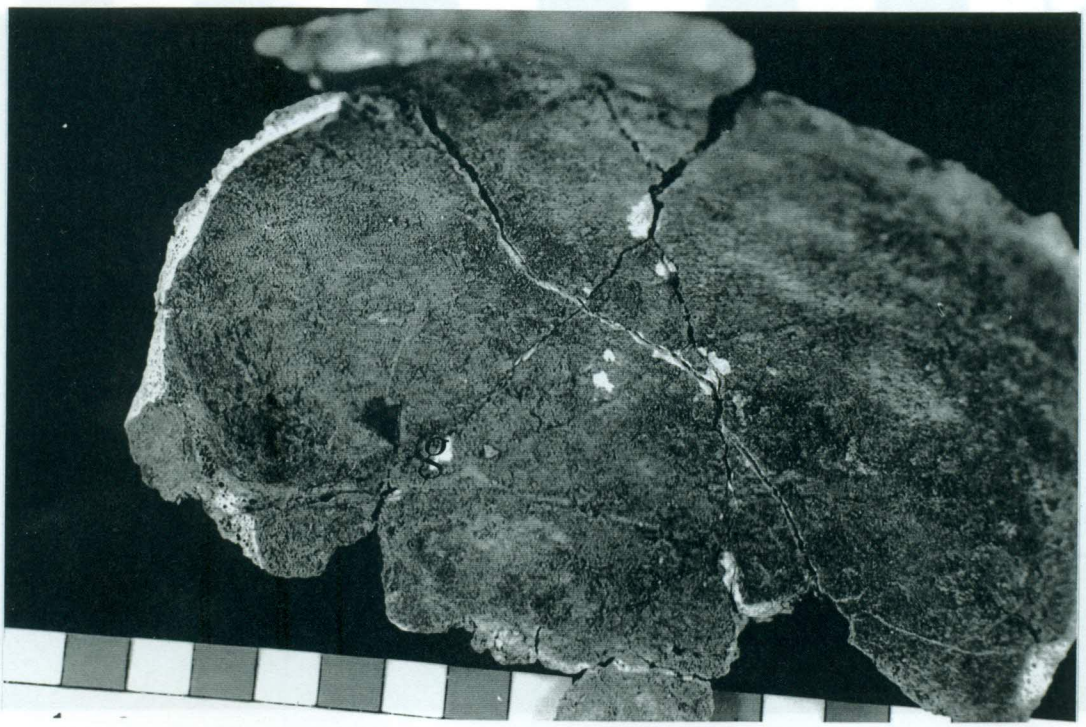


PLATE 64: Subadult F34.026 right parietal's meningeal grooves, in particular the grooves posterior to the orbit, where deeper than those of the left side.



PLATE 65: Subadult F34.026 showed structural variation in the right cerebral surface of the sphenoid greater wing, as a rather thick edge exceeding the normal range when compared with the cerebral surface of juvenile E35.022.



PLATE 66: Subadult F34.026's frontal crest seems to be of normal size, when compared to the high and sharp frontal crest of juvenile E35.022.



PLATE 67: Juvenile E35.022 coronal suture had a had a square-shaped perforation with a step-like structure leading to the perforation on the postero-lateral side.



PLATE 68: Juvenile E35.022 left parietal ectocranial surface with a depression.

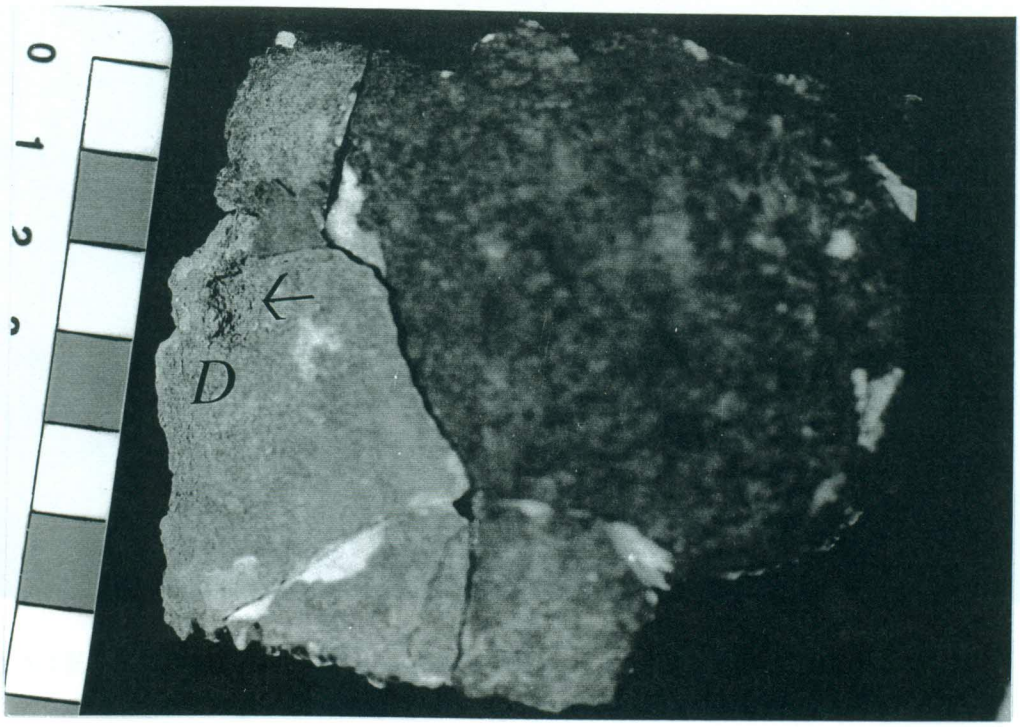


PLATE 69: Juvenile E35.022's parietal fragment with a depression on the ectocranial surface that seems to had antemortem appearance.



PLATE 70: Juvenile G34.022 has possible evidence of squatting facets on the dorsal surface of both tali heads.



PLATE 71: Grave F34 had the remains of two distal and intermediate hand phalanges, that could be representative of a fetus.

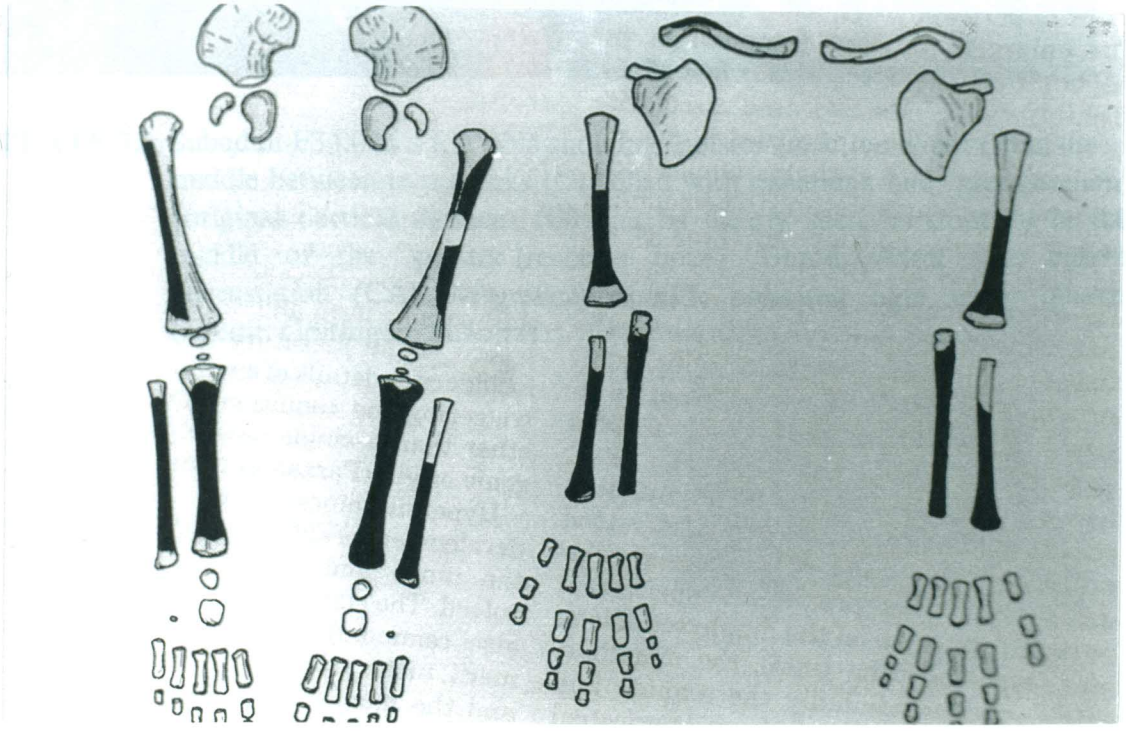


PLATE 81: Distribution of cortical diaphyseal proliferation on the upper and lower limbs as reported by Tayles (1996).

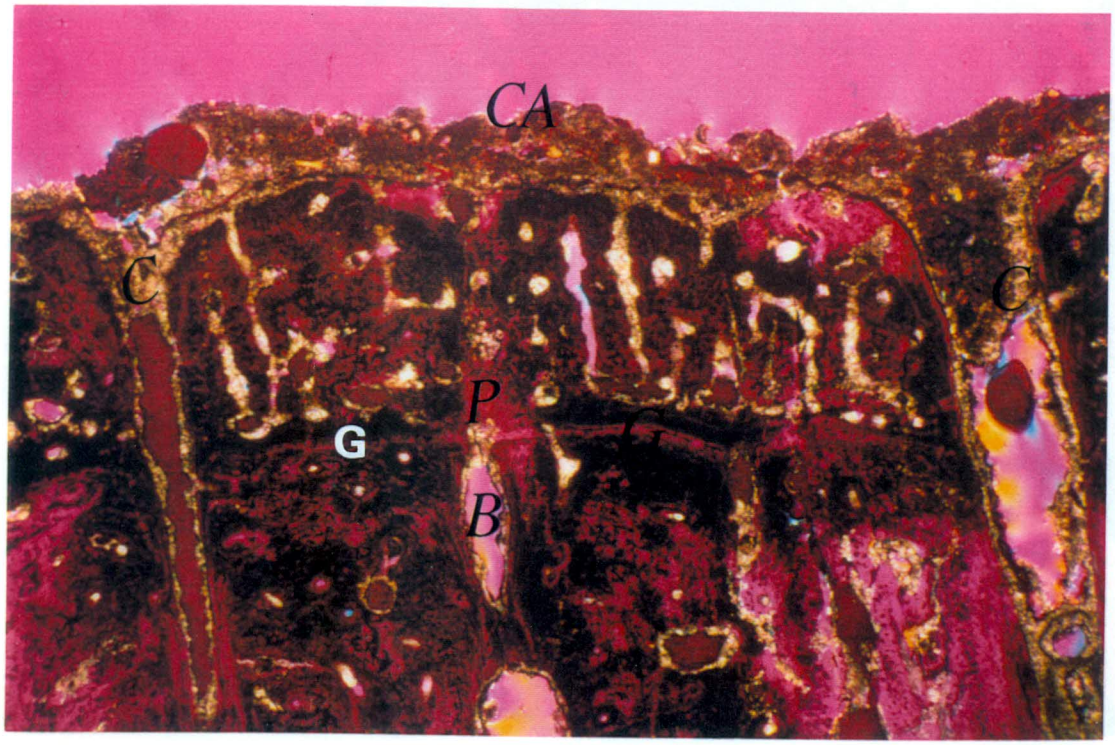


PLATE 72: Subadult F34.026's left tibia showing 'polster'(reactive bone) (P) in the middle between two cracks (C) (filled with minerals), and 'grenzstreifen' (original cortical surface) (G) can be clearly seen horizontally in the middle of the 'polster'(reactive bone). Blood vessel (B), calcite encrustation (CA). Magnification x25; polarised light using quartz. (Credit: Göttingen, Schultz)

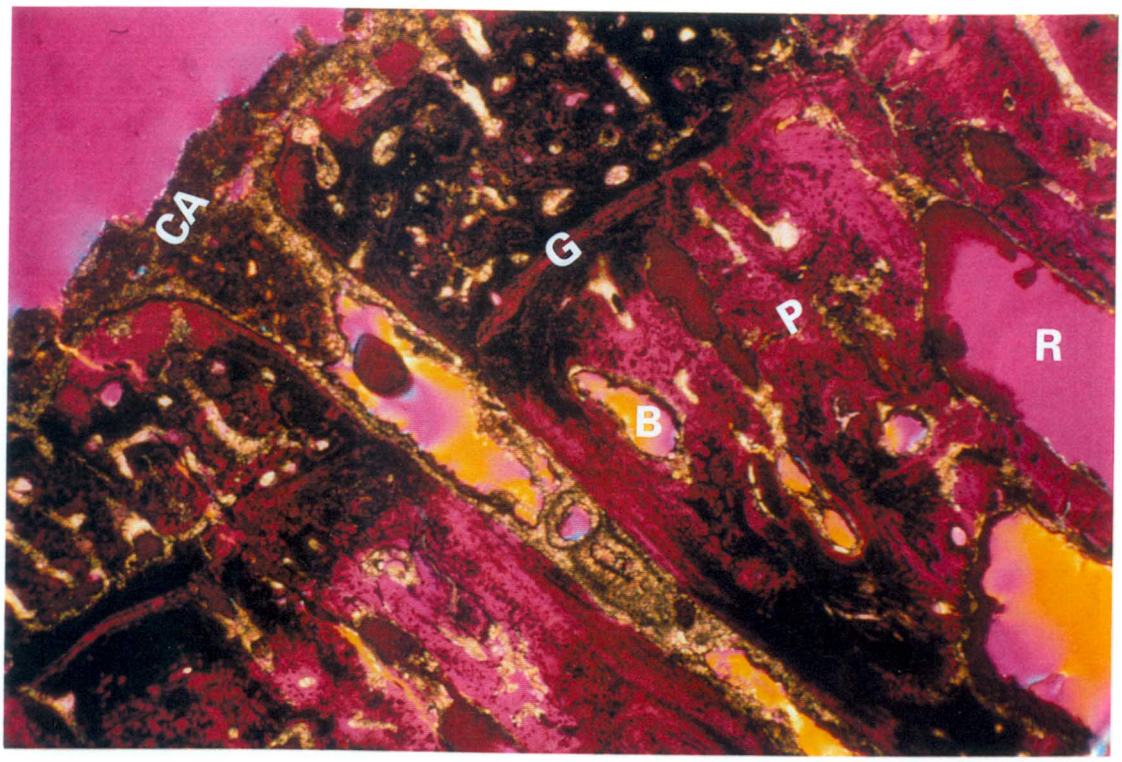


PLATE 73: Subadult F34.026's left tibia, this section is the right side of the above plate (72) showing continuation of 'polster'(reactive bone) (P). 'Grenzstreifen'(original cortical surface) (G) can be clearly seen horizontally in the middle of the 'polster'(reactive bone). The bottom side show resorption caps (R), Blood vessel (B), calcite encrustation (CA). Magnification x25; polarised light using quartz. (Credit: Göttingen, Schultz)

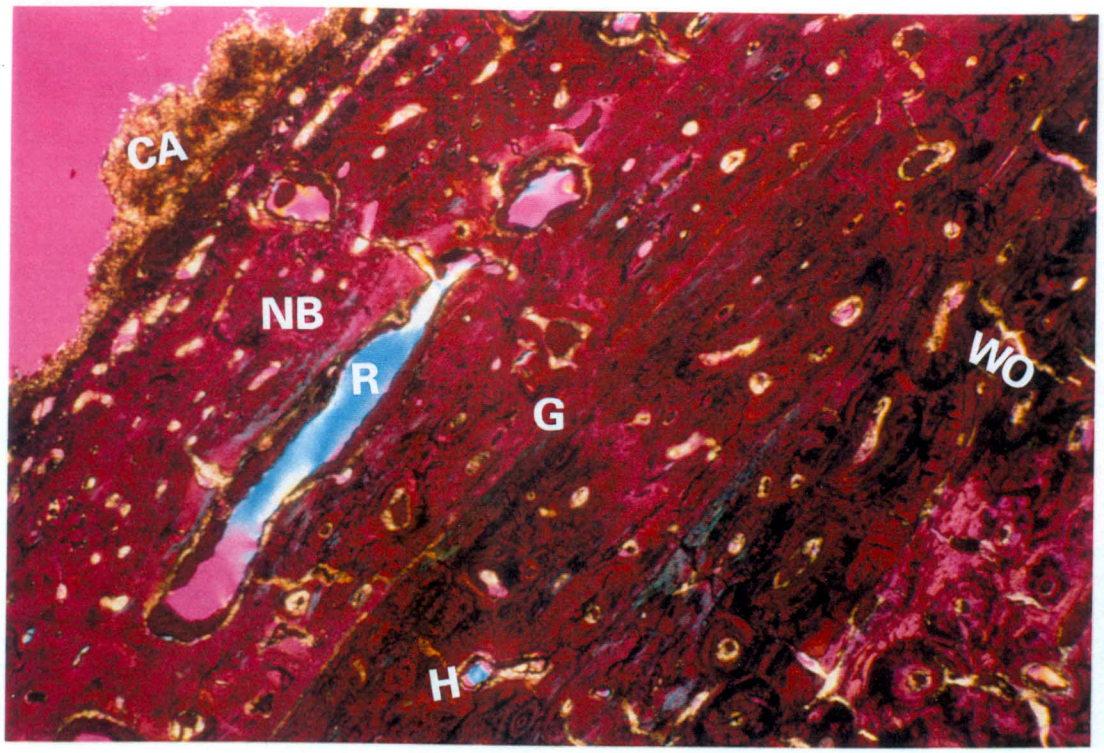


PLATE 74: Subadult F34.026's left femur section exhibiting newly built bone formation (NB) (not polster) with resorption caps (R); however, the newly built bone is separated from the original primary cortical bone by the 'grenzstreifen'(original cortical surface) (G). Calcite encrustation (CA), Haversian canal (H), worm-like destruction areas (WO). Magnification x25; polarised light using quartz. (Credit: Göttingen, Schultz)

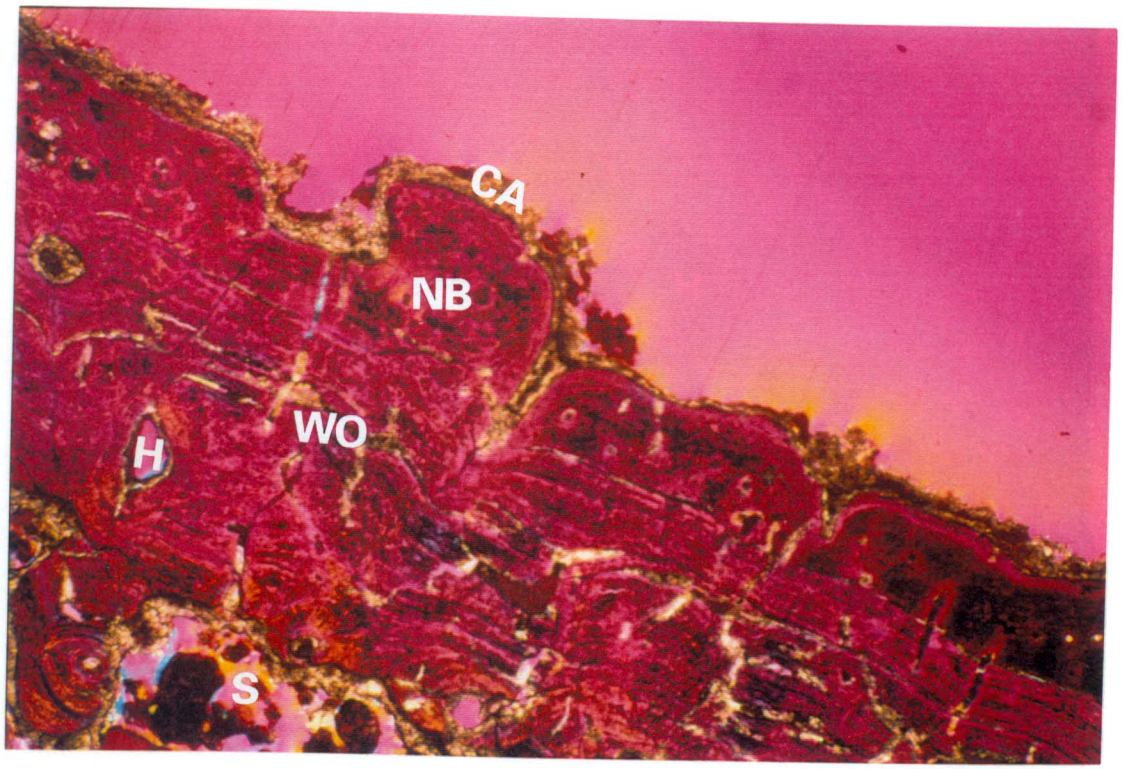


PLATE 75: Subadult F34.026's right fibula section exhibiting newly built bone formation (NB) but does not have the 'polster'(reactive bone) character. The section have an osteoblast reaction sinus hole as a result of a disease process (S). Calcite encrustation (CA) along the outer cortical surface with different degrees of thickness, Haversian canal (H), worm-like destruction areas (WO). Magnification x25; polarised light using quartz. (Credit: Göttingen, Schultz)

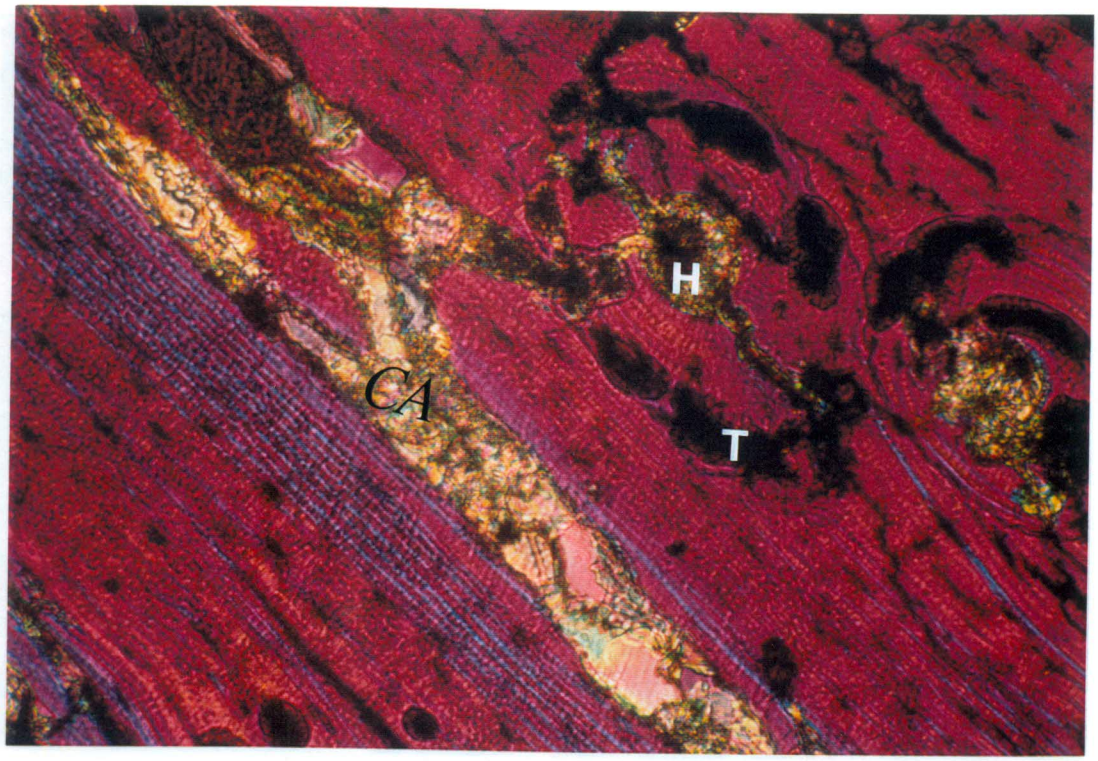


PLATE 76: Juvenile E35.022's left humerus section demonstrates how the calcite (CA) covering the outer surface had infiltrated into the cracks located in the outer surface of the cortical bone. The section also shows focal destruction as the 'lamellate tunnel' feature as indicated by Hackett (1981) where the 'rectangular black' tunnels (T) were arranged in a circular structure surrounding a mineral filled Haversian canal (H). Magnification x100; polarised light using quartz. (Credit: Göttingen, Schultz)

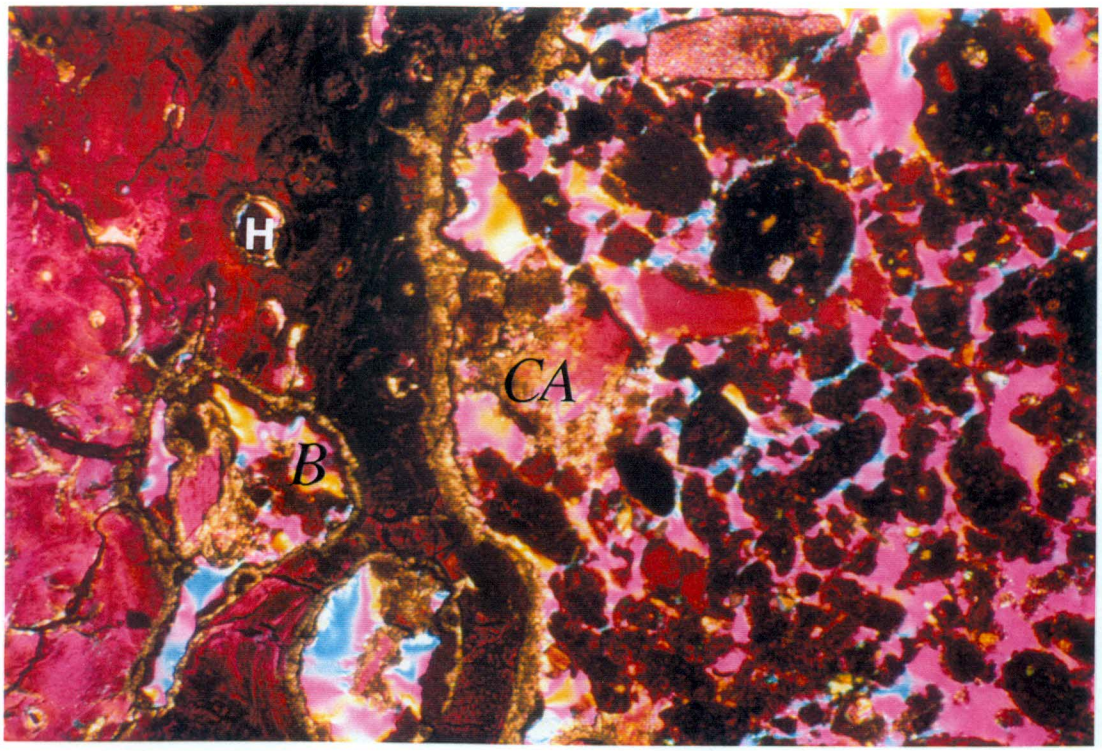


PLATE 77: Infant F34.026 right femur section demonstrates how the calcite (CA) covering the outer surface had infiltrated into the inner edges of the cortical bone, and surrounded the medullary cavity (the right side of section). Blood vessels (B), Haversian canal (H). Magnification x25; polarised light using quartz. (Credit: Göttingen, Schultz)

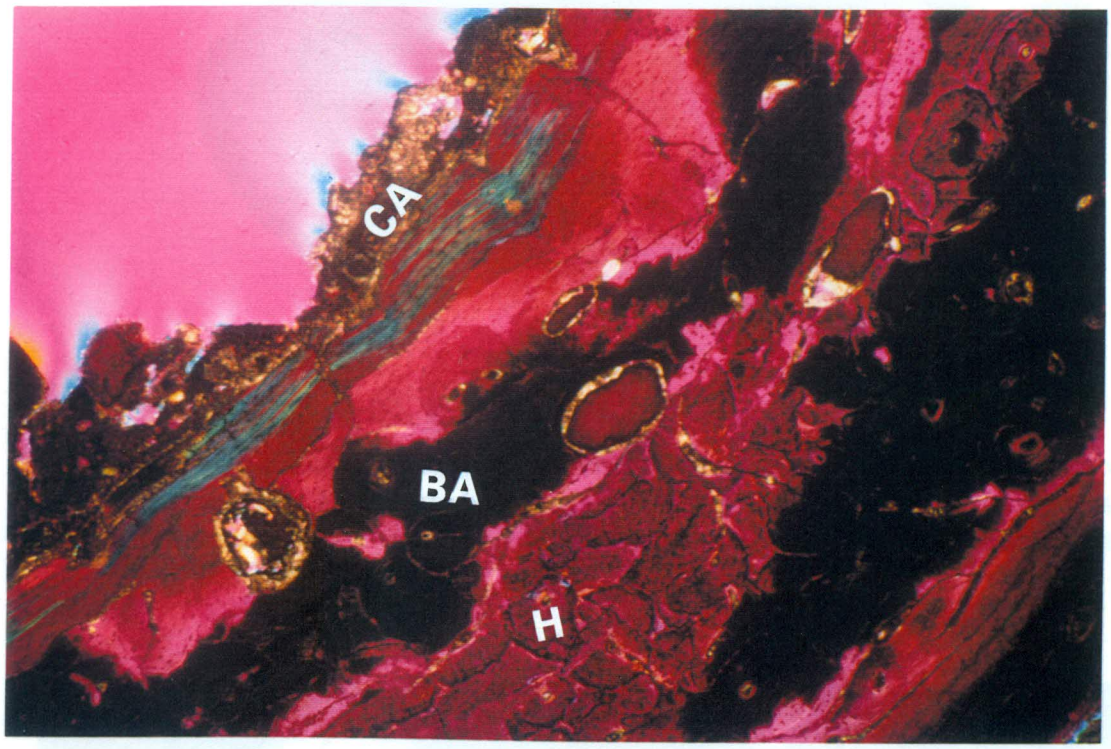


PLATE 78: Juvenile G35b.003's right femur section exhibiting the incomplete bone microstructure. Bone decomposing can be seen as black coloured areas which are the result of air filling the destroyed bone matrix (BA). Calcite encrustation (CA), Haversian canal (H). Magnification x25; polarised light using quartz. (Credit: Göttingen, Schultz)

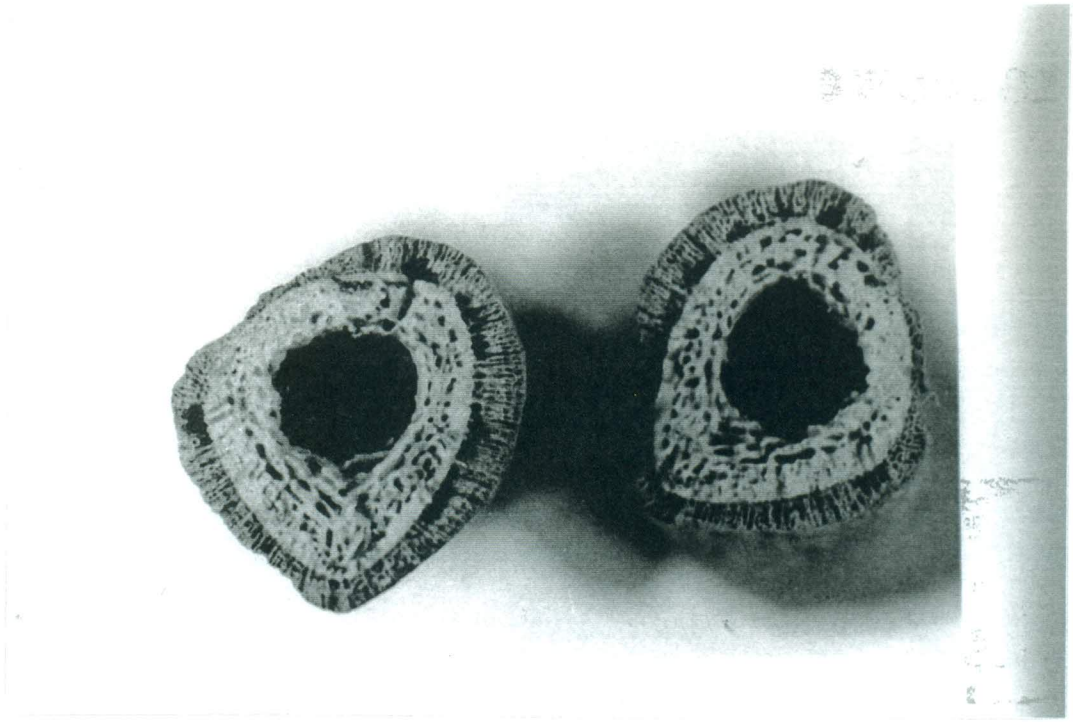


PLATE 79: Tibial section showing extensive proliferation of the sub-periosteal surface, as reported by Tayles (1996). The proliferation is seen as a second layer with a line separating the original cortical bone from the newly built bone.

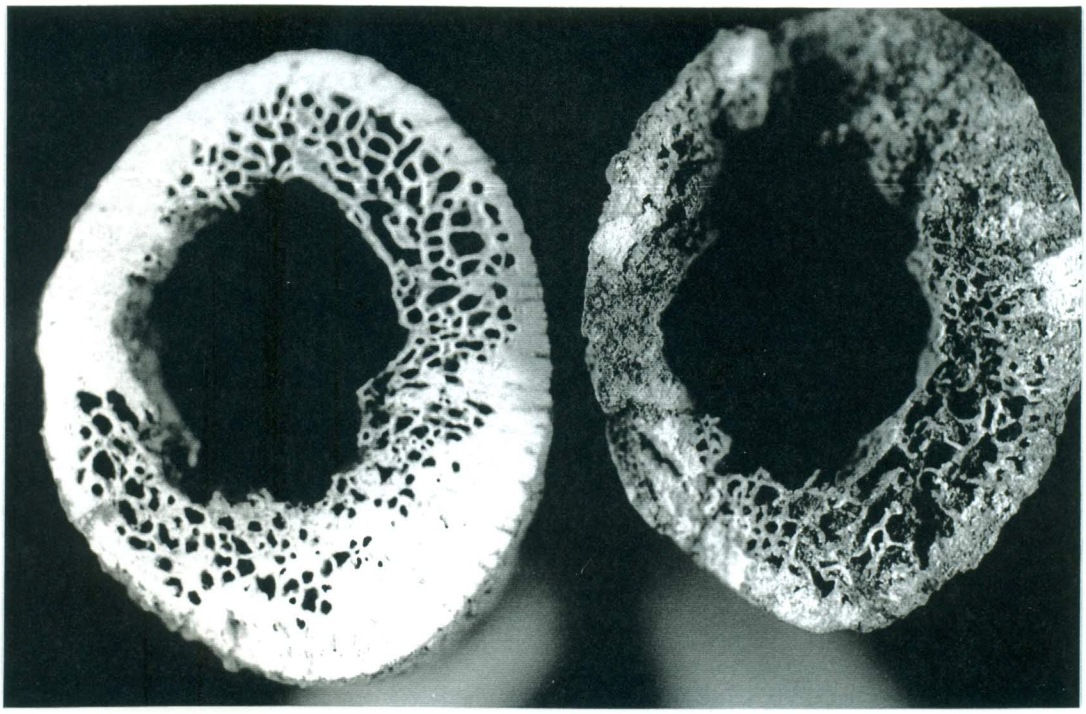


PLATE 80: Subadult F34.026 tibial sections with proliferation of the endosteal surface that appears as an extension of the original cortical bone.

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