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CEMENTUM: DISCOVERING A METHODOLOGY THROUGH A HISTORICAL LENS

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To the Graduate Council:

I am submitting herewith a thesis written by Kortney Dewayne Powell entitled "CEMENTUM: DISCOVERING A METHODOLOGY THROUGH A HISTORICAL LENS." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Comparative and Experimental Medicine.

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CEMENTUM: DISCOVERING A METHODOLOGY THROUGH A HISTORICAL LENS

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ABSTRACT

This light and scanning electron microscopic research documents structure and measures change in cementum of several historic African American burial ground samples dating from approximately 1820-1920. The populations these samples represent are from the First African- American Baptist Church in Philadelphia (PA), the Cedar Grove Baptist Church, Texarkana (AR), and Providence Baptist Church, Memphis (TN).

This research bears dental histological, forensic and historical significance. Of the dental tissues, cementum structure is the lesser known. Because of continual deposition, annuli have been utilized in age estimation. Cementum annuli is potentially a better age-estimation tissue due to its protected alveolar bone location and that utilization of these incremental lines may be more than any other morphological or histological trait in the human skeleton.

There has been only slight research with cementum and even less analyzation using scanning electron microscopy. Here, I obtained high-resolution, three-dimensional topographical images that provide compositional information to the tissue. This analysis provides a metabolic snapshot into the developmental aspect of these individuals.

This focus fosters historical interest due to the one-hundred-year chronology, population, and location of discovery. This time span covers a century encompassing the end of slavery (1619-1865), pre-reconstruction (1865-1867), reconstruction (1867-1877), and the era of Jim Crow Law (1877-1950) which barred African Americans from not only participation in White society, but the inability to receive any quality of healthcare. As a mineralized tissue, cementum structure may have secured the impact of the social restrictions.

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Introduction

Even though teeth have been with humankind since the beginning of time serving primarily as instruments of mastication and tools of survival, their exact functionality has yet to be fully understood. This is made evident as their history is documented extensively over the centuries; from toothaches being considered a curse from God, to their healing being conducted by the performance of rituals and offering off as sacrifices. It is not until 7000 BC that there is a recorded practice of dental procedures that involved the use of tools, such as bows operating as drills. This record of dentistry is further enhanced during the Egyptian Dynasty with the Ebers papyrus. It is one of the most well preserved and extensive texts of the time that notes various ailments of the oral cavity and their remedies (Hussain and Khan 2014).

The History of Dentistry and Its Progression

Throughout antiquity, advancements were made that established, by today's standards, what is considered the basics of dentistry. But it is not until the seventeenth century that the practice of dentistry is evaluated on an anatomical level, and separated from medicine into its own distinguished, but intertwined discipline. It is during this era that anatomist, Adrian Spiegel, recognized the teeth's fixation within the alveolar bone. Furthermore, it is also during this time that, Diemberbroek, a Dutchman, noted the replacement of deciduous teeth after an extraction and theorized that permanent teeth are developed from the roots of the deciduous dentition remaining in the alveoli (Guerini 1909).

It is not until 1678, with the development of the first powerful microscope, does Antoni Van Leeuwenhoek notate the structure of dentine. Shortly afterwards, Jean Duverney, a French anatomist, examines fetal jaws, and at the diminishing of the root cavity with age along with other age-related anomalies (Guerini 1909).

The identification of cementum does not come until the nineteenth century. Further explained in Yamamoto and Hasegawa (2016)," …cementum was first demonstrated microscopically by Fraenkel and Raschkow (1835) and Retzius (1836), and has since become a part of general knowledge in dentistry."

After this initial focus of dental anatomy and histology, there is a one-hundred-and-fifty-year gap before the development of a microscope capable of viewing cementum and its examination. In recognizing the extended periods of scientific breakthroughs; again, it is not until the passing of another century that functionality and form is brought to the understanding of cementum. As cementum is studied, it's appositional growth is utilized in association with wildlife management.

Throughout antiquity and in animal husbandry, age has been estimated by the evaluation of teeth. "Knowledge of the ages of individuals is essential to understanding the rates of growth, onset of sexual maturity, fertility peak, senescent decline and life span, as well as social behaviours" (Spinage 1973:165-187). As mammals have been tested in different environments and their cementum analyzed, it was concluded that instances such as," cold stress is a calcium-consuming process, the lack of available calcium in newly forming cementum could be responsible for the observed hypomineralization. The appositional growth characteristics of dental cementum serve as a record for such life-history events" (Cipriano 2002:21-31). Forensic anthropologists began using it as a means of identification in the early 1980's. During growth, sequential changes assist in the estimation of age, but this metric is only limited to the growth of subadults. As age increases, so does degenerative properties that increase the difficulty in using this methodology (Roksandic, Vlak et al. 2009).

By taking these commonalities into consideration, the question of what causes cementum hyper- and hypo-mineralization, or light and dark banding, in humans begs attention. In Cipriano 2002, that cementum of captive apes were analyzed. This analysis displayed hyper-mineralization based on climate and diet. This raises the question to its reflection within humans.

To analyze this occurrence, historic African American populations were analyzed to assess the value of cementum for age estimation and the accuracy of total cementum annulation (TCA), within historic and deprived populations. Additionally, cementum will be critiqued based on its depiction in microscopy. As mammals display cementum variation based on dietary restrictions during seasonality; this study analyzes members of historic African American populations. Over the span of a century which included social restrictions and inhumane practices such as: slavery (1619-1865), pre-reconstruction (1865-1867), reconstruction (1867-1877), and the era of Jim Crow Law 1877-1950) in the United States.

By analyzing cementum development over this time period, we may become more versed on the characteristics of cementum and its functionality outside of anchoring the tooth. Second, a methodology will be developed for best practice procedures to grind, polish and/or etch historic dental remains. Finally, this research will provide a methodological roadmap on how to analyze cementum in historic and/or modern populations that are socially restricted and/or malnourished.

Cementum

Cementum, from its Latin origin, means quarry stone and was first described by students of Purkinje in 1835. It is a mineralized, avascular tissue that encases the root of the tooth. Its borders create the cemento-enamel junction (CEJ) and the cemento-dentinal junction (CDJ) terminating at the root apex. To understand the importance of cementum, one needs to understand it function. Diagrams of cementum can be found at the end of this chapter in figure 1.1 showing the basic single rooted tooth anatomy, and figure 1.2 showing the basic double rooted tooth anatomy.

The anchoring mechanism of teeth to the jaws is called the periodontium. The word "periodontium" is of Greek origin, meaning around tooth. Specifically, the periodontium, "anchors the teeth to the bone of the jaws, provide interdental linkage to a row of teeth, and seals the oral mucosal openings created by the erupting teeth. Thus, the periodontium comprises four different tissues, e.g., root cementum, alveolar bone proper, periodontal ligament and the gingiva" Schroeder (1986:12). Thus, cementum functions as a glue anchoring the periodontal ligament to the tooth's surface.

In tooth development, cementum is created by cementoblasts, during root formation. This process is called cementegenisis. Histologically, cementum is thicker at the cementoenamel junction. The composition of cementum is approximately 65% inorganic hydroxyapatite, 23% organic collagen, and 12% water. As it is absent of nerves it is nontransitive of pain if damaged. It is composed of an interfibrillar matrix and collagen fibrils. Ireland (2010) describes cementum structure and function beginning with the collagen periodontal ligament which have ends embedded as fibers threaded throughout the cementum. This threading forms Sharpey's fibers. Sharpey's fibers, the extrinsic fibers one of the two characteristics of cementum. To secure cementum to dentin, at the cemento-dentinal junction, there is a hyaline layer.

In the early stages of tooth development within the dental follicle, cementum is initially deposited as acellular, or primary cementum by cementoblasts. At this stage it only covers the root dentine. Cellular cementum, or secondary cementum, which is structurally similar to bone. Is located near the apical-third of the tooth root. Cellular cementum features cementocytes embedded in lacunae, which have cytoplasmic processes linking them to each other by means of canaliculi. These processes are directed towards the periodontal membrane from which they obtain nutrition.

Cementum can be classified into four categories: acellular afibrillar cementum (AAC), acellular extrinsic fiber cementum (AEFC), cellular mixed stratified cementum (CMSC) and cellular intrinsic fiber cementum (CIFC). AAC is in the cervical region cementum encasing enamel in humans. AEFC is another product of cementoblast that provides the ground substance. It is also composed of Sharpey's fibers and lacks cells and may come in contact with AAC. CMSC is another product of cementoblasts and is composed of varied intrinsic and extrinsic fibers. It is most commonly found within the apical one-third of the tooth-root. CIFC is another product of cementoblast, containing cells, but not collagenous fibers. It is mainly found filling in the areas of resorbed lacunae (Schroeder 1986).

After cementegenisis has deposited cementum on the root dentin, it continues appositionally, throughout life. Unlike the other dental tissues, cementum is dependent upon the tooth root's functionally and requirements during eruption and orthodontic restructuring as a result of movement repositioning of the tooth. Cementum is only reabsorbed when there is extreme stress and pressure on the root.

Research has linked the appositional deposition of cementum to growth analysis. The incremental light and dark banding lines created throughout a calendar year, have provided valuable information into the seasonality of wildlife (Weinand 1997). This information was used to detect the seasonality of death within wildlife, as well as serve as an indicator of population longevity. This method has been attempted for age estimation in humans Charles, Condon et al. (1986)

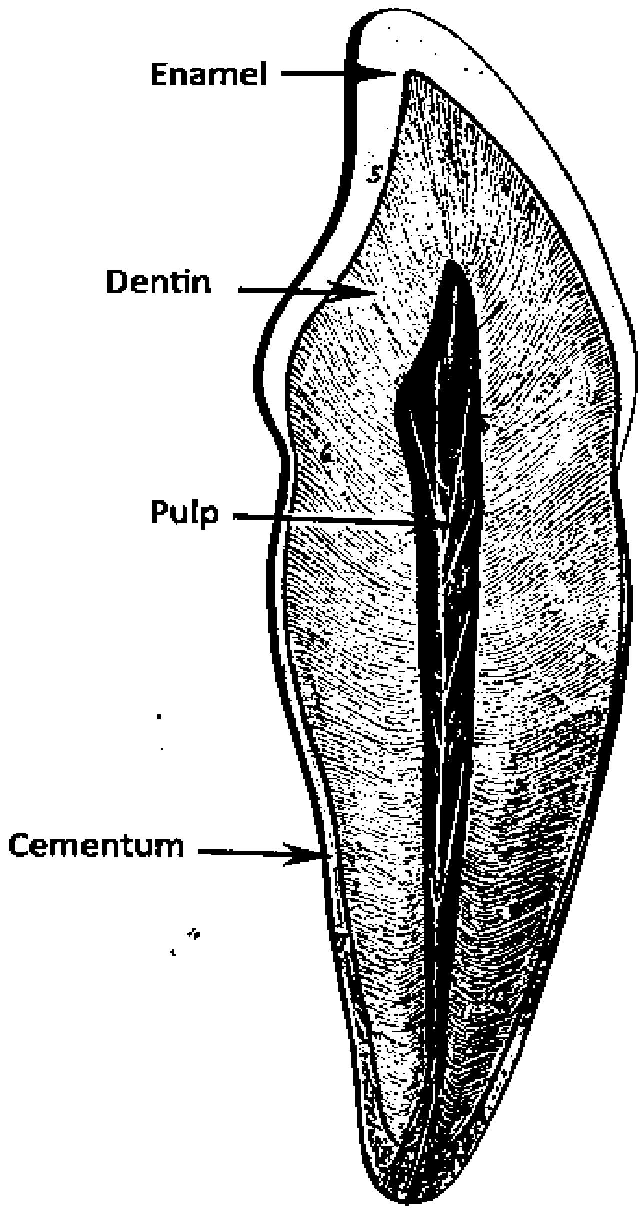

Figure 1.1 Basic Single Rooted Tooth Anatomy. Photo taken by the Human Anatomy Web Site at San Diego Mesa College

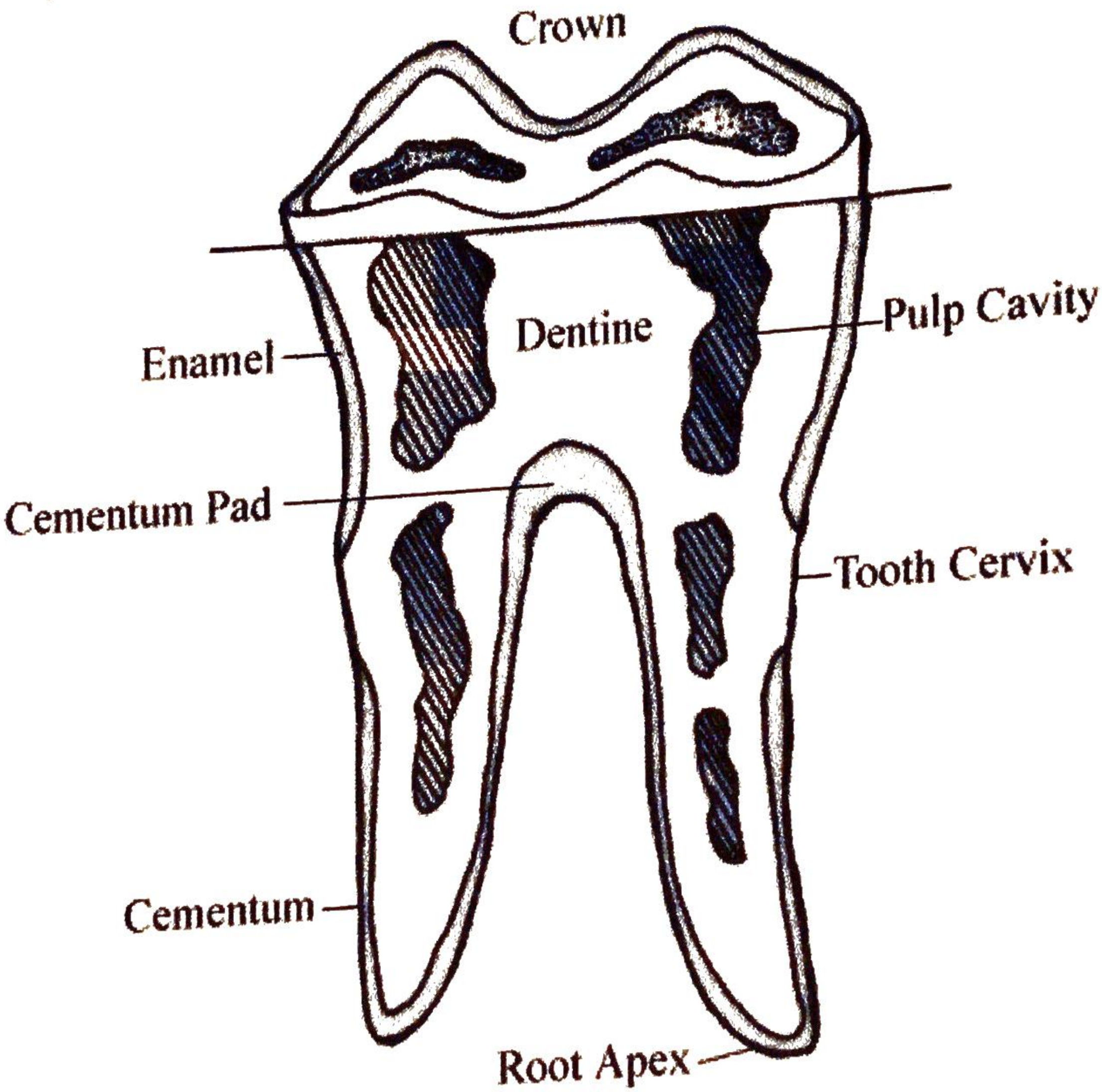

Figure 1.2 Basic Double Rooted Tooth Anatomy (Leigh 1998).

CEMENTUM ANNULATIONS IN WILDLIFE

Throughout the years, archeologists have used the appositional deposition of cementum, of known human prey, to analyze human behavior. As the deposition of occurs, it gradually creates an alternating ring-like anatomical structure, or annulations. By observing this patterning, archeologists can estimate age, in addition to infer environmental and metabolic changes.

Weinand (1997) studied the incremental cemental annuli of white-tailed deer in comparison to mammalian wildlife. This incremental growth banding is found in most vertebrates and invertebrate fauna. Archaeologists are more concerned with its ability to discern season at death to interpret human 'hunting' behavior and understanding death rates of certain species. This infers cultural understanding of the annual and life-long foraging habits of the animal kingdom.

Lieberman and coworkers initiated the ground work on cementum in 1969. Their research indicates that banding is a result of photo-periodicity, climate, and hormonal cycles. Lieberman (1995), suggests that the light and dark annulations are a result of variations in relative mineralization and colloagen orientation due to nutritional and biochemical stress associated with the differences in seasonal food quality. This was proven by changing the texture of goats' food and observing the cementum annuli with scanning electron microscopy. Through this research, he determined that coarser foods influenced mastication which altered the orientation of the extrinsic collagen Sharpey's fibers. This additional-biomechanical stress caused the fibers to orient more on the y-plane, relative to the x-axis of the tooth. In addition to scanning electron microscopy, Lieberman also used microradiographic analysis to detect changes in the mineral density. This research improves our understanding of how function affects form.

AGE ESTIMATION USING TOOTH CEMENTUM ANNULATIONS

In forensic science age estimation is a crucial tool used in the identification of decomposed human remains, skeletonized or comingled. Once a body becomes decomposed, visual identification becomes impossible. As a result, forensic scientists turn to skeletal and dental markers to discover and create methods to help estimation of age, sex, ancestry and stature. Age estimation is arguably the most challenging (Senn and Weems 2013).

Reliability and accuracy in age estimation is of high importance, as its use sometimes has legal implications such as: narrowing the search possibilities of unknown victims, estimating the age at death, differentiating cluster victims, aiding immigration services in the processing of undocumented immigrants, awarding of social benefits, and establishing the legal age of majority amongst other things (Lewis and Senn 2010).

Established methodology in age estimation is supported by scientific rationale. There are numerous methods of conducting biological age estimation from skeletal and dental remains. From bone, these include analysis of the pubic symphysis, sacro-iliac surface, sternal ends of the ribs, medial clavicle, cranial sutures and hand-wrist bone development. Furthermore, there are numerous gross and radiographic methods using teeth. Regardless of the tissue analyzed, as age increases, the accuracy of the estimation decreases.

Of these different markers, pubic symphysis is regarded as the most widely used, reliable, anthropologic determinant of age estimation in medicolegal cases. “Current pubic symphyseal aging methods combine morphological characteristics associated with developmental changes during the period immediately following adolescence with degenerative changes spanning the latter portion of the age spectrum” (Dudzik and Langley 2015). It utilizes a scoring system, and therefore, its accuracy is dependent upon subjectivity of the forensic anthropologist conducting the analysis. As age increases, the accuracy of age estimation decreases creating an increase in the potential age interval. Charles and coworkers (1986) describe the best level of accuracy at approximately plus or minus 5 years, featuring less precision in certain aspects.

The utilization of the teeth are frequently and more prominently used as a means to estimate age in recent years. As dentistry has evolved, different scientifically derived methods of age estimation have come into fruition such as: development and eruption charts, aspartic acid racemization radiocarbon, root length and translucency, and most noted in this research – root cementum apposition (Lewis and Senn 2010). Figures 3.1 through 3.4 shows the detailed documentation through the Atlas of Human Tooth Development and Eruption, Descripton of Moorrees’ Stages, Dental Age Assesment Procedures, and the Adult Dental Age Assessment Technique Chart respectively.

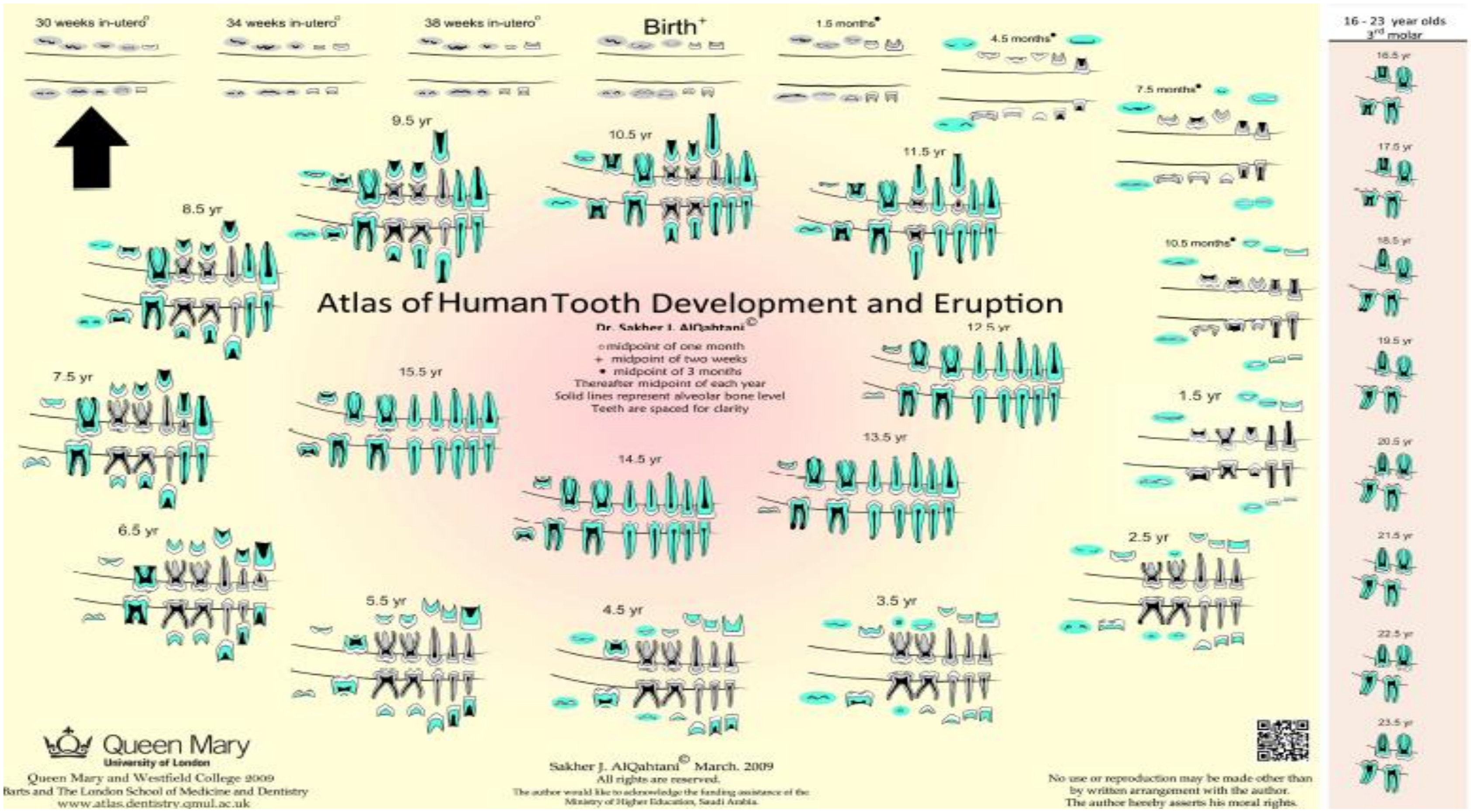

Figure 3.1 Atlas of Human Tooth Development and Eruption (Qahtani 2012).

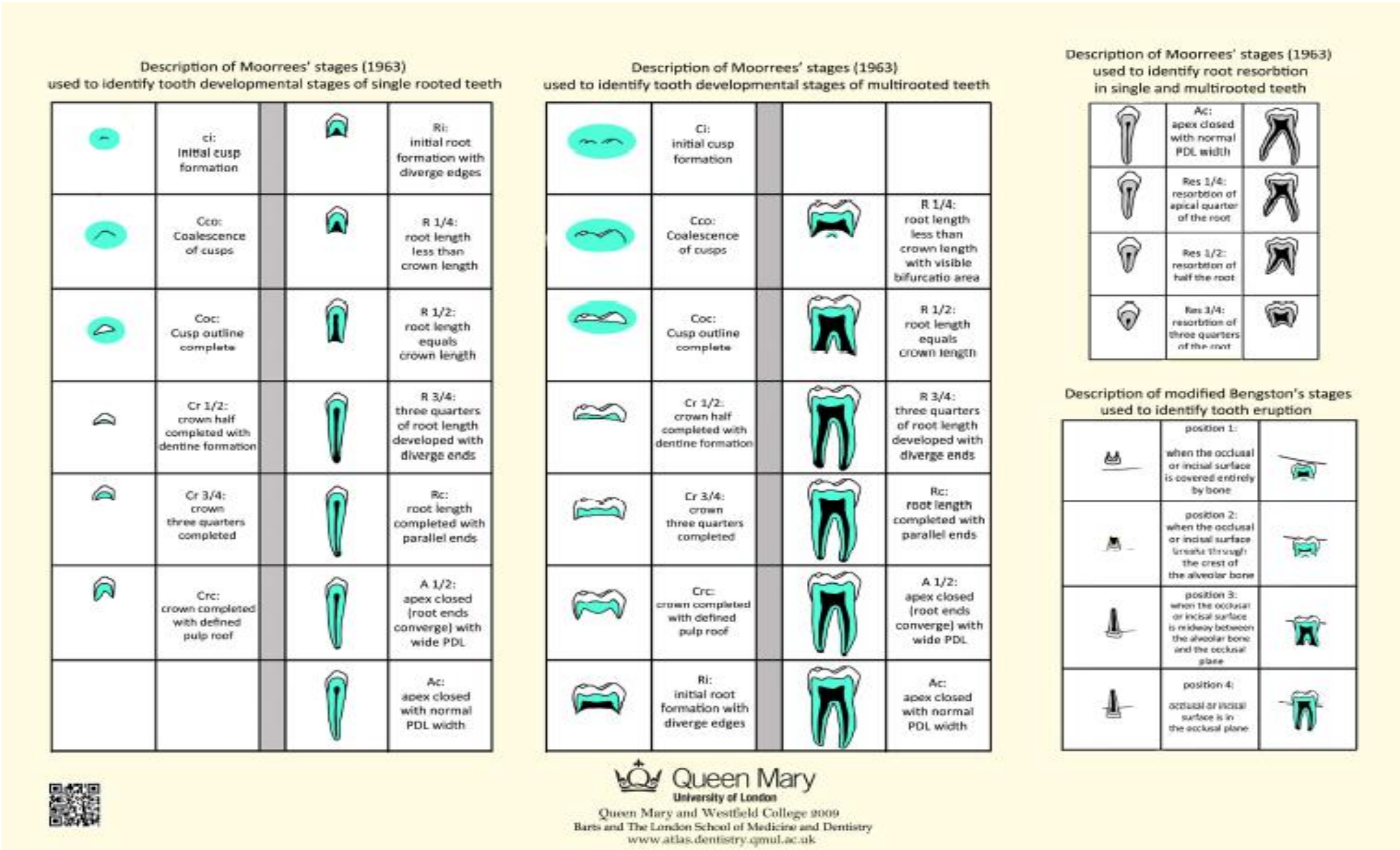

Figure 3.2 Descripton of Moorrees' Stages (Qahtani 2012).

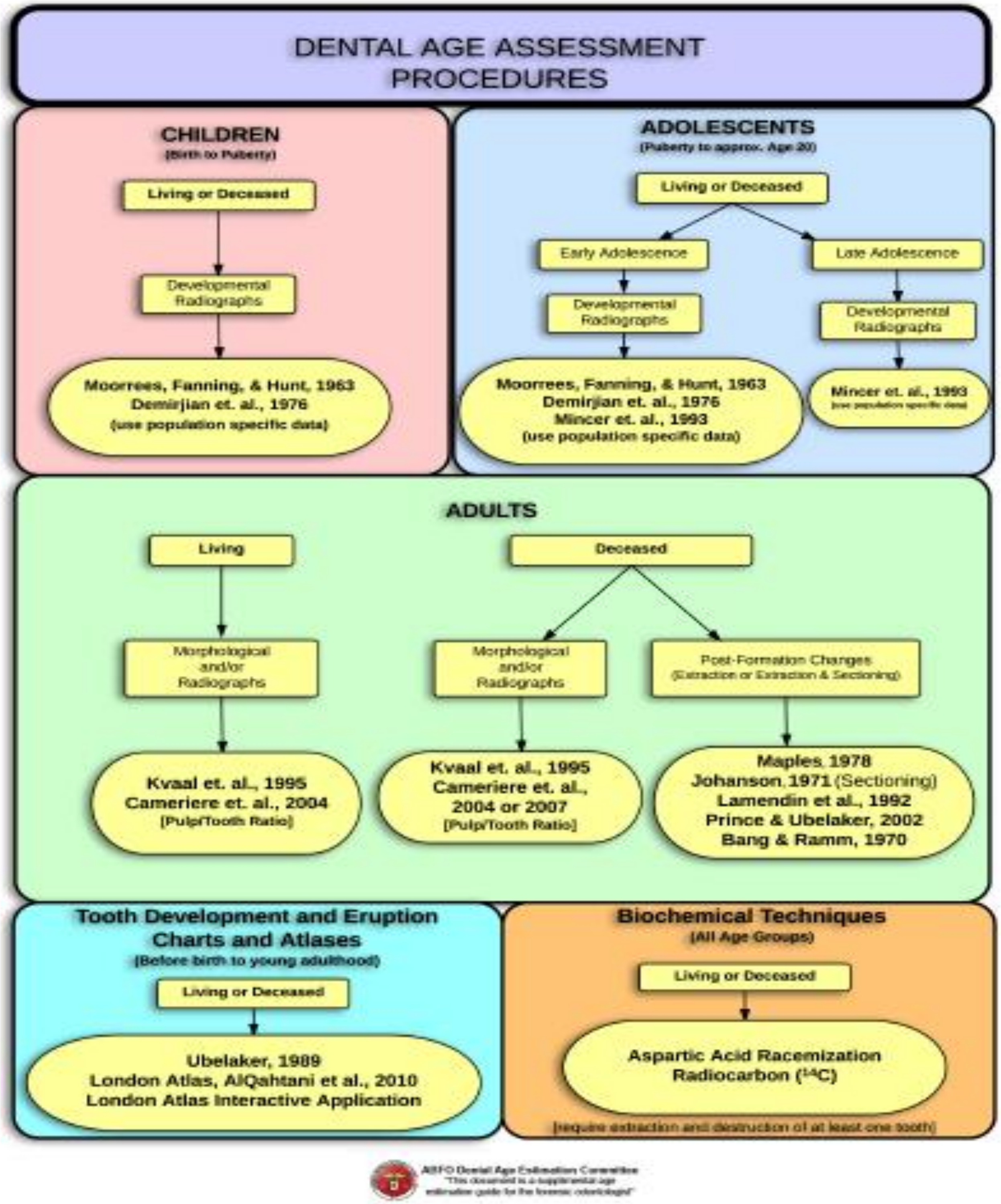

Figure 3.3 Dental Age Assessment Procedures (Odontology 2016).

Adult Dental Age Assessment Technique Chart

Adult DAE Technique	Level of Uncertainty Used	Age Interval of Individuals Studied	Intact or Sectioned Teeth	Measurements Required	Best Teeth Utilized (order to use)	Can Teeth Have Pathology, Restorations/No Restorations/Trauma/Rotations	Sex/Ancestry Specific
Lamendin et al.,1992	Mean Error (ME) +/- 10 Years	40-80 Years	Intact	Root Length, Root Translucency and Periodontal Attachment	Any Single Rooted Incisor Tooth (Maxillary Centrals Best) Ideally Use Multiple Teeth Use Labial Surface	Teeth Can Have Minimal Restorations However There Should be No Periapical Pathology	Non Sex Specific (Study Performed on a French Population of European Ancestry)
Prince/Ubelaker, 2002	Standard Deviation (SD)	30-69 Years	Intact	Root Length, Root Translucency and Periodontal Attachment	Use Single Rooted Teeth : Maxillary Centrals>Laterals>Mandibular Incisors>Canines>Bicuspids Use Labial Surface	Teeth Can Have Minimal Restorations However There Should be No Periapical Pathology	Sex Specific and Population Specific for European-American and African American (Hispanic Populations Acceptable)
Bang/Ramm, 1970	Standard Deviation (SD)	25-75 Years	Intact/Sectioned	Root Translucency	Single Rooted Teeth Only: Maxillary #'s 4-13, Mandibular #'s 20-29 and Can Use Mesial Root #'s 3, 14 19 and 30 and Distal Root #'s 3, 14, 19 and 30. Use Labial Surface	Teeth Can be Restored/Nonrestored and Have Pathology/Trauma Associated with Them	Non Sex And Non Ancestry Specific
Kvaal et al., 1995	Standard Error of Estimate (SEE)	20-87 Years	Intact (Radiographic Technique)	Ratios: Tooth/Root Length, Pulp/Root Length and Pulp/Tooth Length (Measured on the Mesial) and Pulp/Root Widths at 3 Different Levels (9 Measurements and 8 Calculations/Tooth)	Maxillary Arch > Mandibular Arch Maxillary Centrals>Laterals> 2nd Bicuspids and Then if Necessary, Mandibular Laterals>Canines>1st Bicuspids. Ideally use Multiple Teeth	Teeth Must Have No Restorations/Trauma/Pathology/Rotations and be in Normal Function	Non Sex And Non Ancestry Specific (If Using Mandibular Laterals Then This Technique is Sex Specific)
Johanson, 1971	Standard Deviation (SD)	23-79 Years	Sectioned	Attrition, Periodontosis, Secondary Dentin, Cementum Apposition, Root Resorption and Root Translucency	Use Single Rooted Teeth (Incisors and Bicuspids) From Maxillary and Mandibular Arches	This Method Recommends Examination of the Dental Occlusion Noting the Number of Teeth Present, Location and Potential Habits of the Individual. Teeth Utilized Should be Vital and Not be in Traumatic Occlusion or Have Evidence of Previous Trauma (Including Extensive Caries or Restorations)	Non Sex And Non Ancestry Specific
Maples, 1978 (ST Position Weighted Formulas Only)	Standard Error of Estimate (SEE)	10-90 Years	Sectioned	Root Translucency (T) and Secondary Dentin (S) Formation	Can Use Any Tooth *Except* Third Molars (Best Tooth is 2nd Molar)	This Method Recommends Examination of the Dental Occlusion Noting the Number of Teeth Present, Location and Potential Habits of the Individual. Teeth Utilized Should be Vital and Not be in Traumatic Occlusion or Have Evidence of Previous Trauma (Including Extensive Caries or Restorations)	Non Sex And Non Ancestry Specific
Cameriere et al., 2004	Standard Error of Estimate (SEE)	18-72 Years	Intact Radiographic Technique (Images Taken in Labio-Lingual Direction)	Ratios of Pulp/Tooth Area (AR) and Pulp/Tooth Width at Mid-Root (c)	Maxillary Canines	Teeth Must Have No Restorations/Trauma/Pathology/Rotations and be in Normal Function	Non Sex And Non Ancestry Specific
Cameriere et al., 2007	Standard Error of Estimate (SEE)	20-79 Years	Intact Extracted Tooth Radiographic Technique (Images Taken in Labio-Lingual and Mesial Directions)	Ratios of Pulp/Tooth Area	Maxillary and Mandibular Canines	Teeth Must Have No Restorations/Trauma/Pathology/Rotations and be in Normal Function	Non Sex And Non Ancestry Specific

Note: All of these Dental Age Estimation Techniques Will Tend to Underestimate the True Chronologic Ages of the Elderly (>80 Years) and Overestimate the True Chronologic Ages of Young Adults (<35 years)

Figure 3.4 Adult Dental Age Assessment Technique Chart (Odontology 2018).

Root cementum apposition, tooth cementum annulation, or cementum annuli has been increasingly used by forensic anthropologist for its low error rate. Measurement of cementum deposition has been used to estimate age. It has been observed histologically that a years' time is equal to two deposition layers, indicated by contrasting light and dark banding. Charles et. al., (1986) reviewed the history of cementum annulations used on humans in forensic science. The use of cementum annuli for age estimation can be properly introduced as followed:

> Recently, Stott and coworkers (Stott et al., 1982; Naylor et al., 1985) described the application of a method of human age-at-death estimation based on counts of incremental cementum layers or annulations. These layers are assumed to be added yearly. Layering in cementum andor dentin has been identified in virtually every group of mammals, and their use in age determination is routine among wildlife biologists (Grue and Jensen, 1979; Klevezal' and Kleinenberg, 1967; Morris, 1978; Spinage, 1973; Stallibrass, 1982).

They (Stott and coworkers) described the use of human age-at-death estimation based on counts of incremental cementum layers or annulations. Additionally, they note the annual deposition of each layer is seen by cutting thin, ground sections of the apical-third part of the tooth root.

Because these annulations are a biologically created development pattern, the use of cementum annulations has become a more accurate estimator of age. Charles and coworkers describe Stotts' error values as ranging from 0.5 to 2.0 years once the average eruption time was added.

However, the common use of cementum annulation is still tentative. Because of the biological structure and its physiological background as a thin sheath is hard to elucidate, well and in a manner, that is able to be repetitively reproduced (Wittwer-Backofen, Gampe et al. 2004).

ENSLAVED AFRICAN-AMERICAN BIO-HISTORY

America was first colonized in 1607 by the establishment of Jamestown, Virginia. In less than two-hundred years civil discourse led to independence. It was not until 1776-1783 that The United States was established as a sovereign nation. In less than fifty years, civil discourse takes its toll again as represented by the Trans-Atlantic Slave Trade, emancipation, pre- and post-reconstruction, and the era of Jim Crow. Because of the economic and social pressures during this era; this chapter will focus on the how these experiences impacted African Americans.

The effects of the slavery are still present in today's society, more than four-hundred years after its fruition and approximately one-hundred fifty years after its abolishment. Little is known of the diet, health, nutrition, disease, and metabolic demand that slavery and its social/ethical constructs had on African Americans (Brooks 2005). The objective of this bio-history chapter is to analyze and review the research done on the remains of each respective population. This analysis will provide background information on this population of individuals.

Cedar Grove Baptist Church – Texarkana (AR)

In the 1980s, Cedar Grove Baptist Church cemetery was discovered on the south bank of the Red River near Texarkana, Arkansas (see figure 4.1). This discovery exposed 104 unmarked and 9 marked graves. These were exhumed and reburied nearby. These graves were excavated, removed, analyzed and relocated. The Red River had previously destroyed numerous graves (see figure 4.2-4.4).

Members of the Cedar Grove Baptist Church included slaves and several generations of their descendants, whose lives conceivably spanned pre-Emancipation (prior to 1865), Reconstruction (1865-1880), and post-Reconstruction (1880-1927). This chronology was established through artifacts and clothing in the grave, coffin hardware and church records detailing the site and burial practices.

The area surrounding Cedar Grove Baptist Church is best described as a dilapidated community of nutritionally-deprived farmers and sharecroppers Analysis of this population revealed: a high subadult mortality rate, females outnumbering males 21 to 15, a mean age of 38 years, and active/or healed pathological skeletal lesions indictive of infections (see figure 4.4).

Periostitis was also found within the subadult population. Periostitis indicates uterine and congenitally-acquired infections, which are pathognomonic for treponemas associated with maternal syphilis. Other credible causes for the high mortality rate includes an area filled with tetanus, diarrhea, worms, fever, and most notably, malaria. A visual representation of dental remains can be found in figures 4.6 and 4.7.

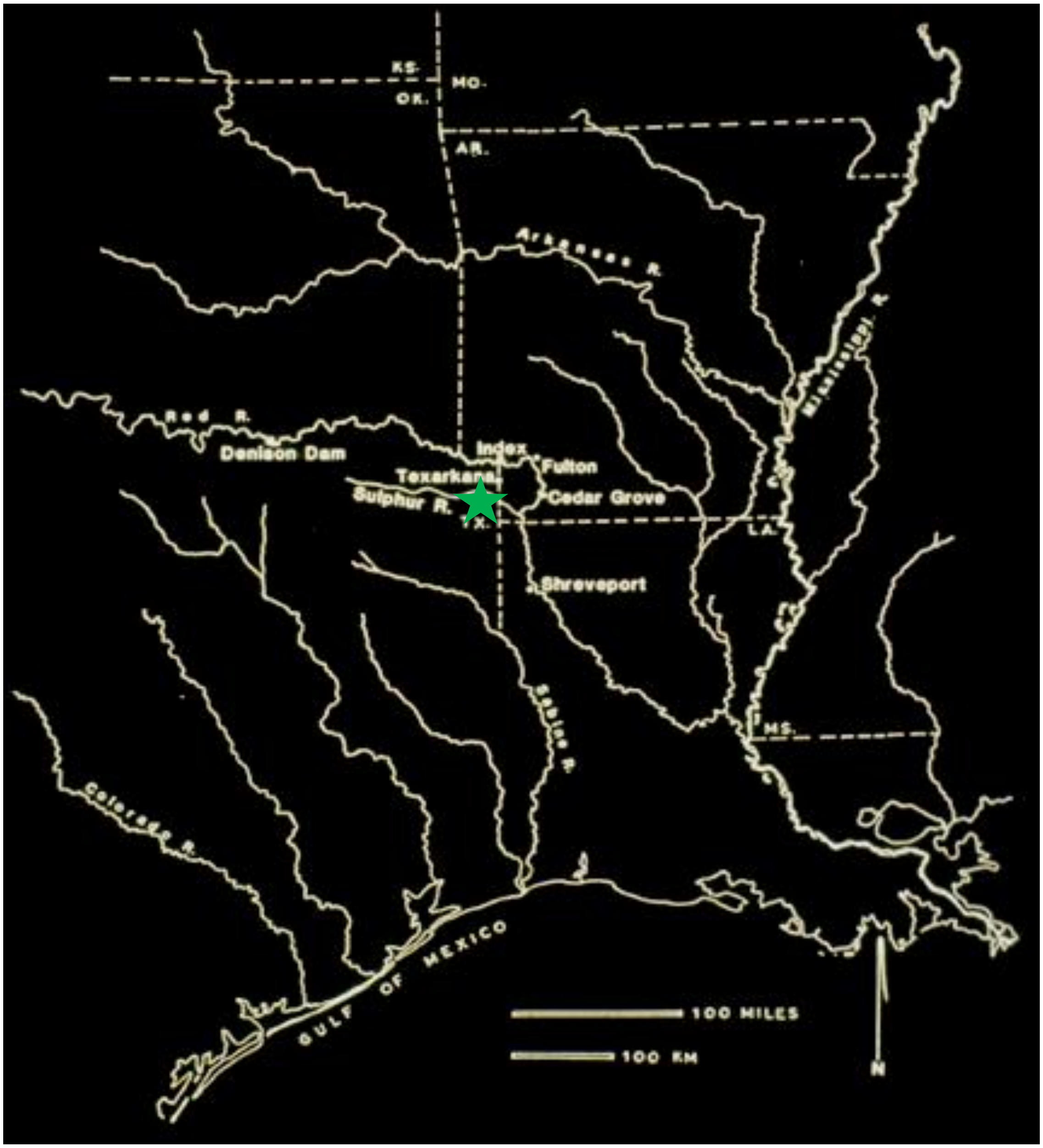

Figure 4.1 Map displaying the area of Cedar Grove and Texarkana, AR.

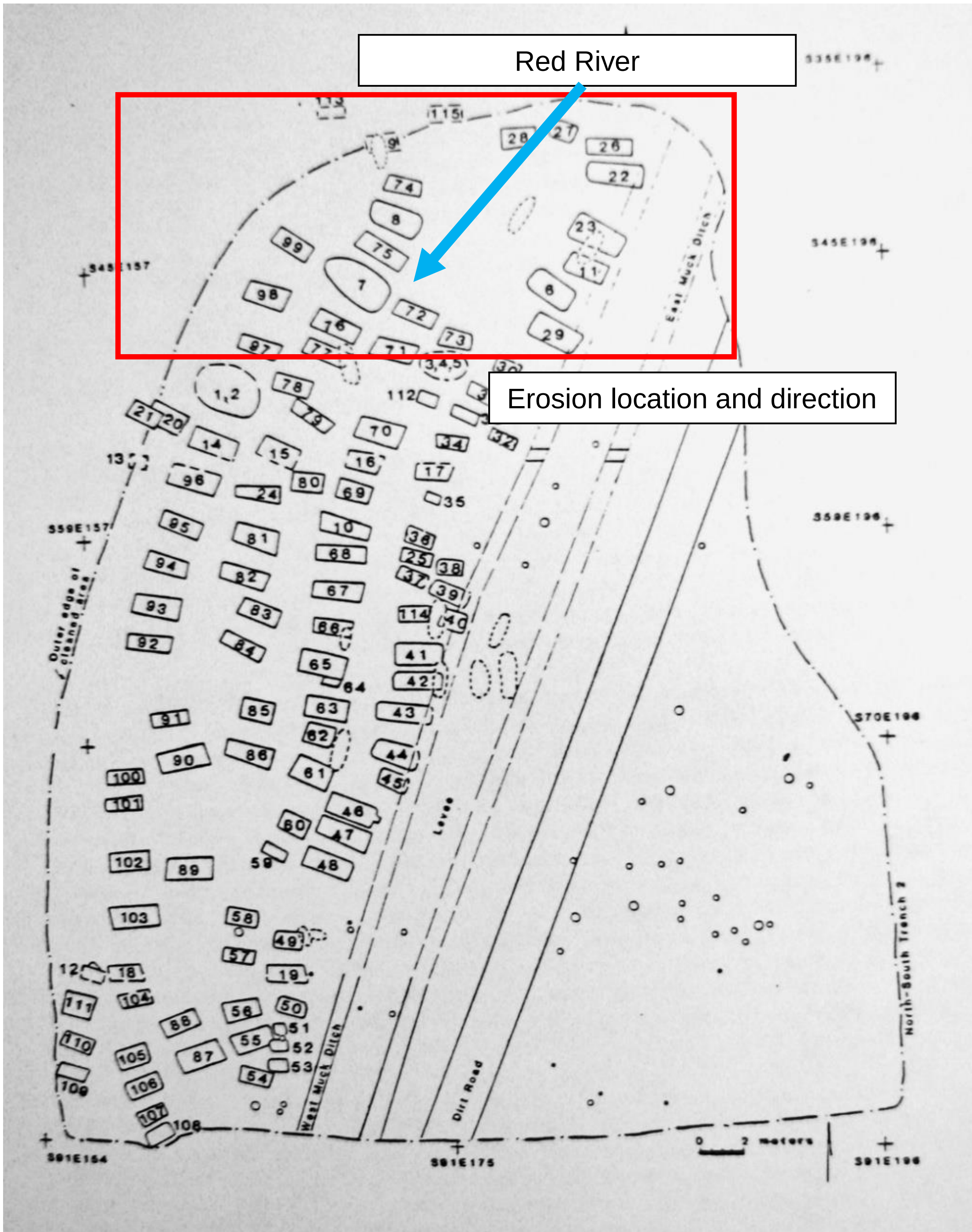

Figure 3-1. Historic burials in the direct impact zone. The dashed outlines indicate prehistoric burials.

Figure 4.2 Historic burials in the direct impact zone.

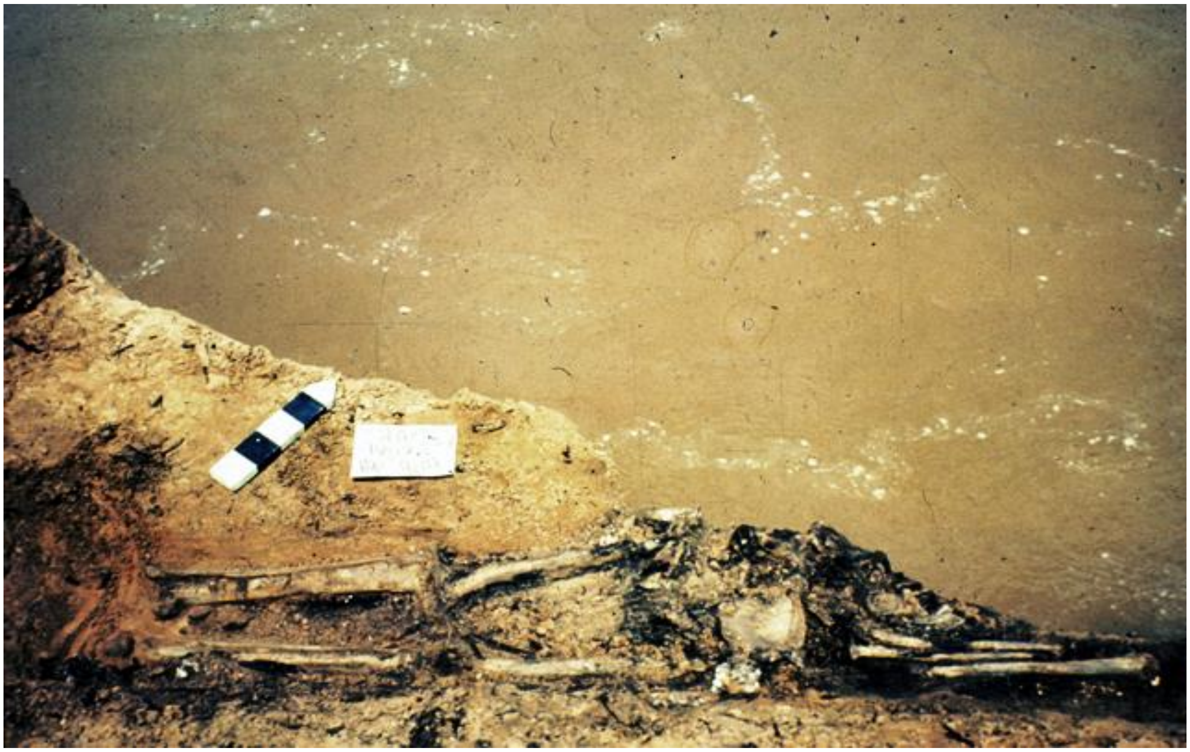

Figure 4.3 25-foot drop-off created by erosion that destroyed 9 sets of remains.

Figure 4.4 Illustration of sharecroppers working.

Figure 4.5 Photo of remains estimated at +/- 10 years of age at Cedar Grove.

Figure 4.6 Condition of oral dentition found in human remains at Cedar Grove.

Figure 4.7 Photograph of mandible and teeth of remains at Cedar Grove.

First African-American Baptist Church Philadelphia - (PA)

The history and culture of the First African-American Baptist Church was anthropologically documented by Marks (1993), beginning with its discovery in 1980 at the corner of Vine and Eighth streets in Philadelphia. During the construction of the Philadelphia Center City Commuter Rail Tunnel in Philadelphia, Pennsylvania, 140 urban African-American burials were discovered leading to the, excavation of: 39 females, 36 males, and 60 subadult remains.

This population's death dated approximately between 1823-1842 (see figure 4.8). The remains had an average lifespan of 40 years of age and an early female mortality rate, ranging between 16 and 34 years (see figure 4.9). Additionally, this population was characterized by poor nutritional health, seen through the high frequency of enamel hypoplasia and dental caries. Caries was more frequent in males than in females as was a greater childhood morbidity rate. Additionally, mineral deficient diets were noted through the findings of pathological lesions such as porotic hyperostosis and cribra orbitalia.

These statistics reflect the state of life during the second quarter of the nineteenth century (see figure 4.10). This period was plagued with racially motivated riots, kidnappings, murders and gang violence. However, skeletal analysis of the remains did not feature a high frequency of skeletal trauma.

During this challenging period for African-Americans, the church served as a cushion to daily life providing a financial aid and suppressing poverty (see figure 4.11). These benefits were most important as African-Americans were often denied the ability to develop wealth as a result of segregation.

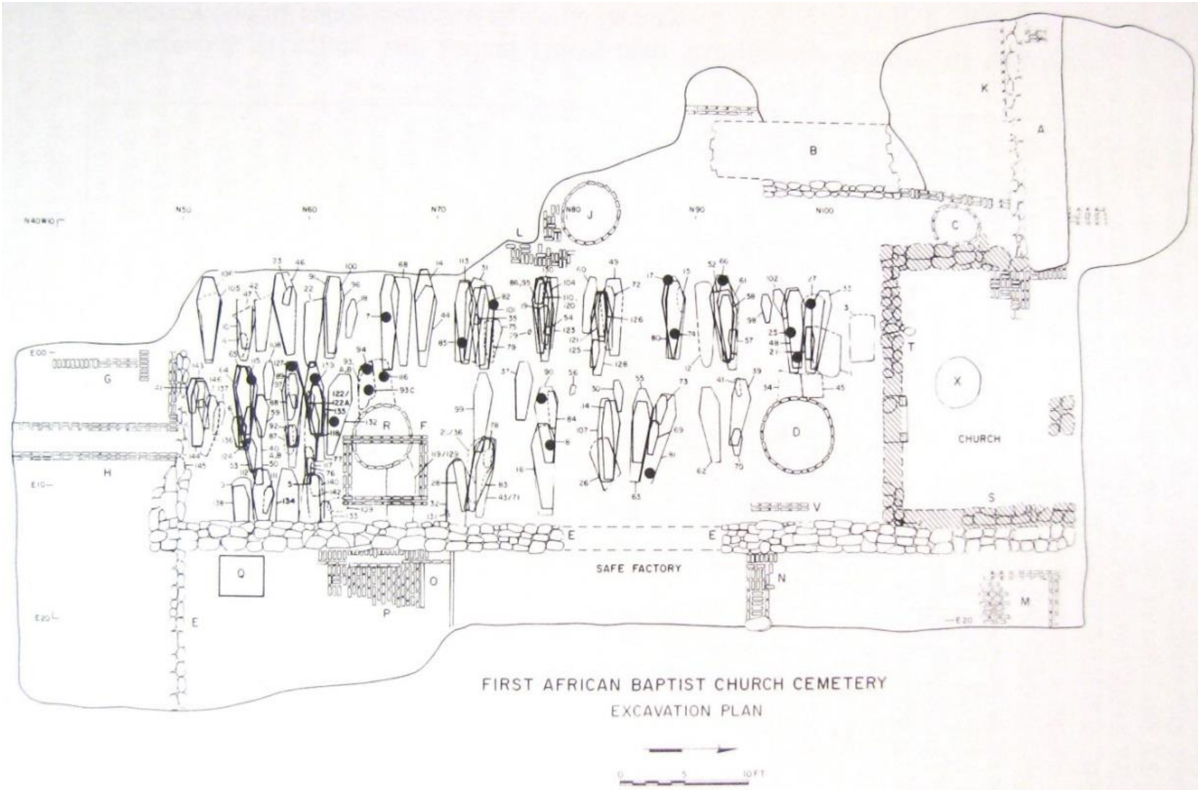

Figure 4.8 First African Baptist Church Cemetery Excavation Plan.

Figure 4.9 Children overlooking the excavation process (Marks 2015).

Figure 4.10 Photo of remains found with artifact.

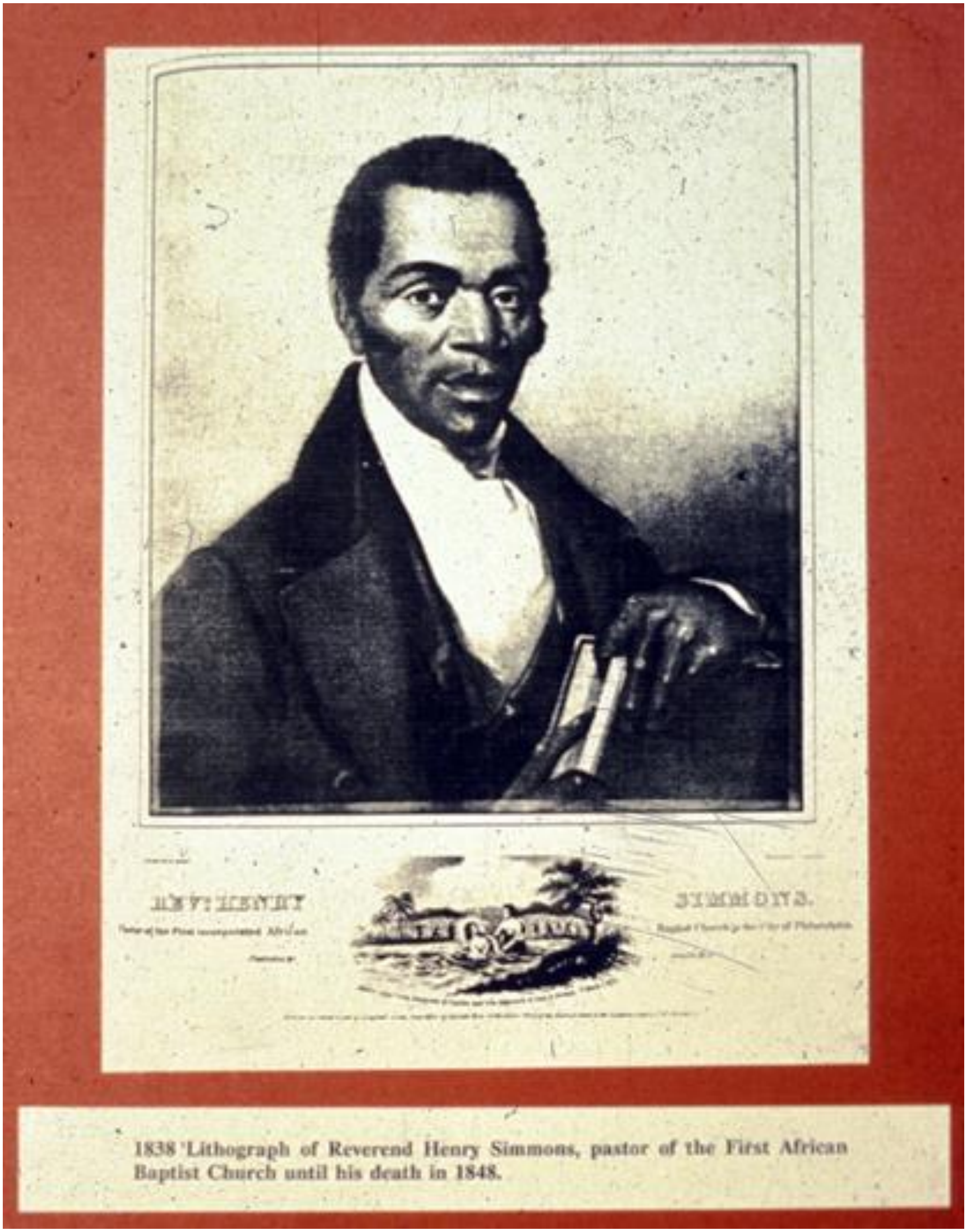

Figure 4.11 1838 Lithograph of Reverend Henry Simmons, pastor of the First African Baptist Church until 1848.

Providence Baptist Church - Memphis (TN)

The history of Providence Baptist Church is greatly provided by Rebecca Wilson, who also serves as a primary source to the excavation and analysis of the burial site.

In 2003, an unmarked cemetery was discovered during a renovation process being conducted at the Memphis-Shelby County Airport (see figures 4.12-4.16). This cemetery was later found to belong to The Providence Baptist Church, of the Oakville suburb of Memphis, Tennessee. Also referred to by its archeological code 40Sy619, Providence Baptist Church was active during the late to early 19th and 20th centuries.

According to county archives, the Church was first established in 1886, with deed records dating as far back as July 27, 1899. The one-acre plot of land that the church and cemetery occupied was purchase for $100 by church leaders: William Branch, Joe Wyatt, and Gustus Glover. Using the Bureau of Labor Statistics consumer price index, inflation of the dollar rises an average of 2.87%, annually; the equivalent purchasing power equates to $2,895.37.

A physical church building did not appear on surveyor maps until 1916. Archaeological investigations place its use around the time of acquisition through 1935 determined by aging of the hardware used on the coffins.

In 1928, the church sold its property to the city for $650 for expansion of the municipal airport. In 1937, no structures were found on record, but a cemetery was present. As the cemetery was thought to be associated with the church, data from the city's directory listed the church as having different locations in 1935, 1940, and in 1953 a complete address and name change was noted. As it is known today, the Providence

Missionary Baptist Church does not claim lineage to the original Providence Baptist Church and its cemetery.

During the airport renovation, approximately 20% of the cemetery was impacted, resulting in the exhumation of 65 burial sites containing 62 individuals. Of these remains, personal artifacts were recovered included: pieces of newspapers, personal belongs and tombstones identifying persons and their age(see figures 4.17 through 4.19). Individuals were later matched with obituaries found in dated newspapers.

The condition of the remains varied from poor to excellent (see figure 4.20). The best preserved remains were those that had been buried underneath some of the original runway asphalt. As a result of coffin material and drainage issues, remains outside of the original runway path had the most damage.

Seven years before the establishment of the church, Yellow Fever plagued the city of Memphis from 1878 and 1879. During this time 25,000 citizens fled the city, 5,000 relocated into camps in the surrounding areas. There were more than 5,000 deaths recorded and the city lost its charter in 1879. The city was not re-incorporated until 1893.

Wilson details the occupations of African American as the following:

Vital statistics for the Memphis area indicate that most of the Black population not involved in agricultural activities were employed in menial and unskilled tasks. By 1920, agriculture was still the predominant employment opportunity for Tennessee Black males with 360,000 individuals; domestics came in second with 180,910; and mining, manufacturing, trade, and transportation completed the top occupations (Coomer 1920). Black female occupations were domestics at 56,000, followed by agriculture at 36,000, and finished out by manufacturing and clerical jobs (Coomer 1920). From 1880 and 1920 there was a shift from agriculture to manufacturing. In 1880, 49.4 percent of the Black population of the Unites States was employed in agriculture, while only 25.6 percent 16 were employed in manufacturing (Coomer 1920). By 1920, only 27.2 percent of Blacks were involved in agriculture with 33 percent employed in manufacturing (Coomer 1920).

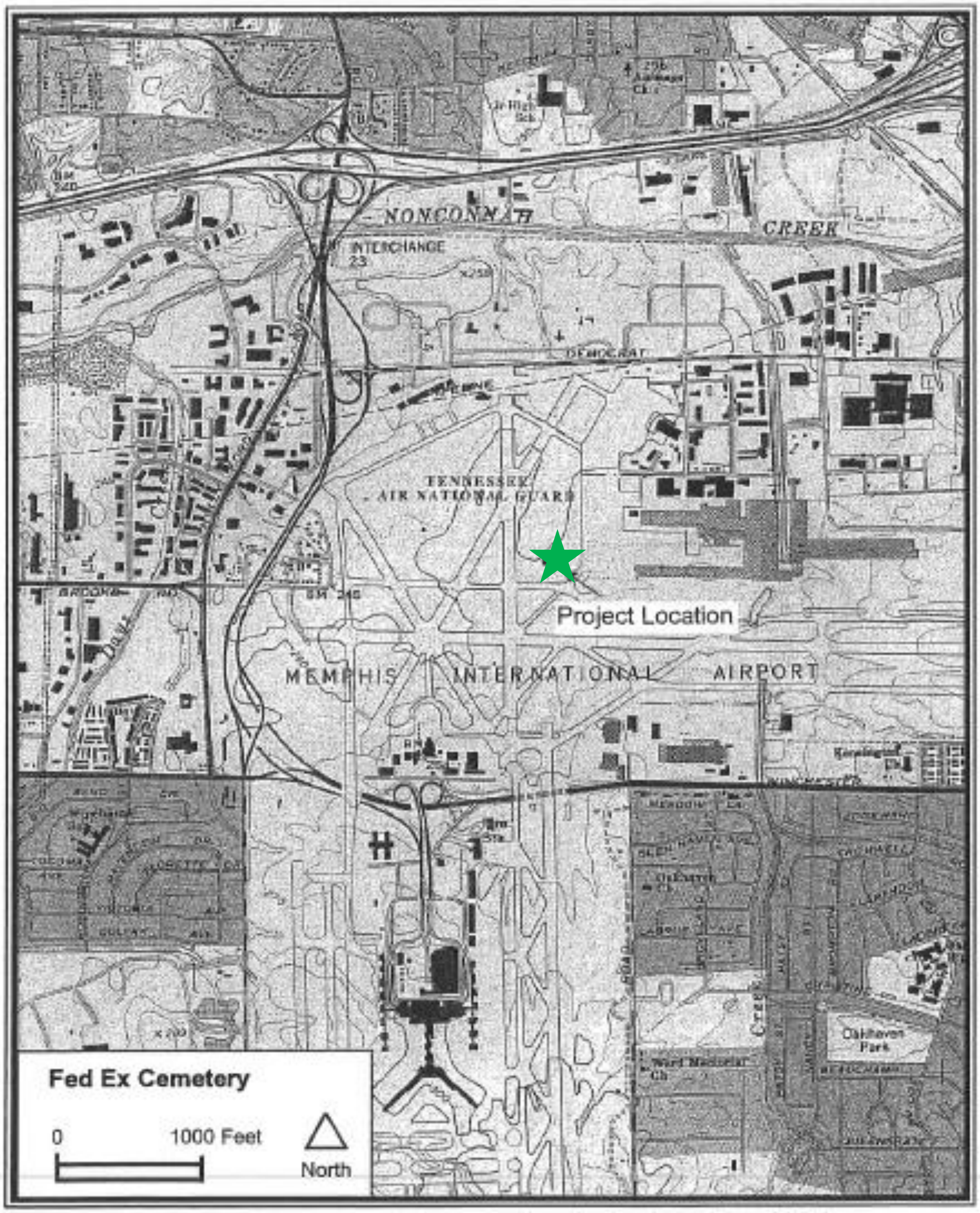

Figure 4.12 Project location of Providence Baptist Church Cemetery (Weaver 1998).

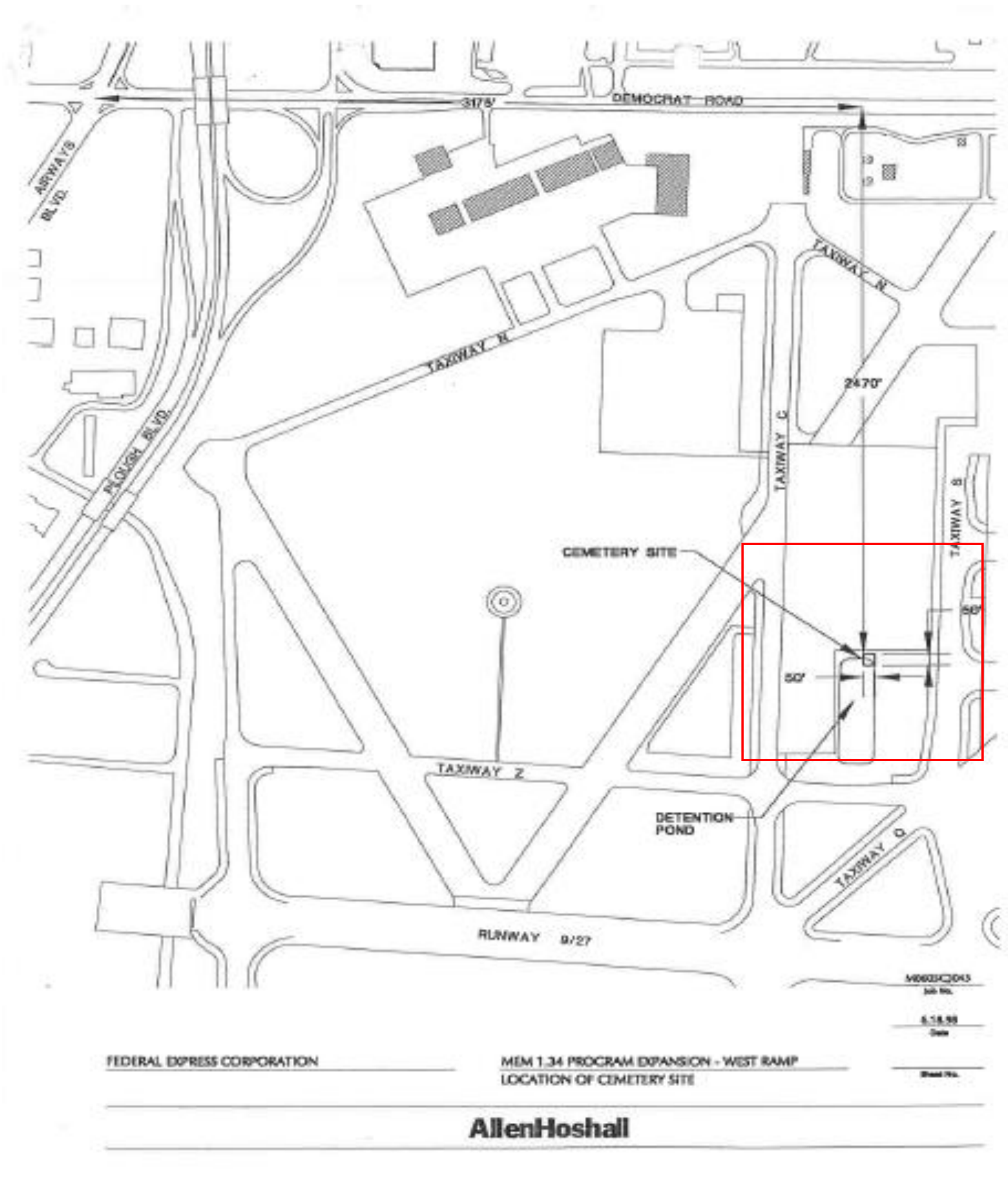

Figure 4.13 Land survey of cemetery site (Weaver 1998).

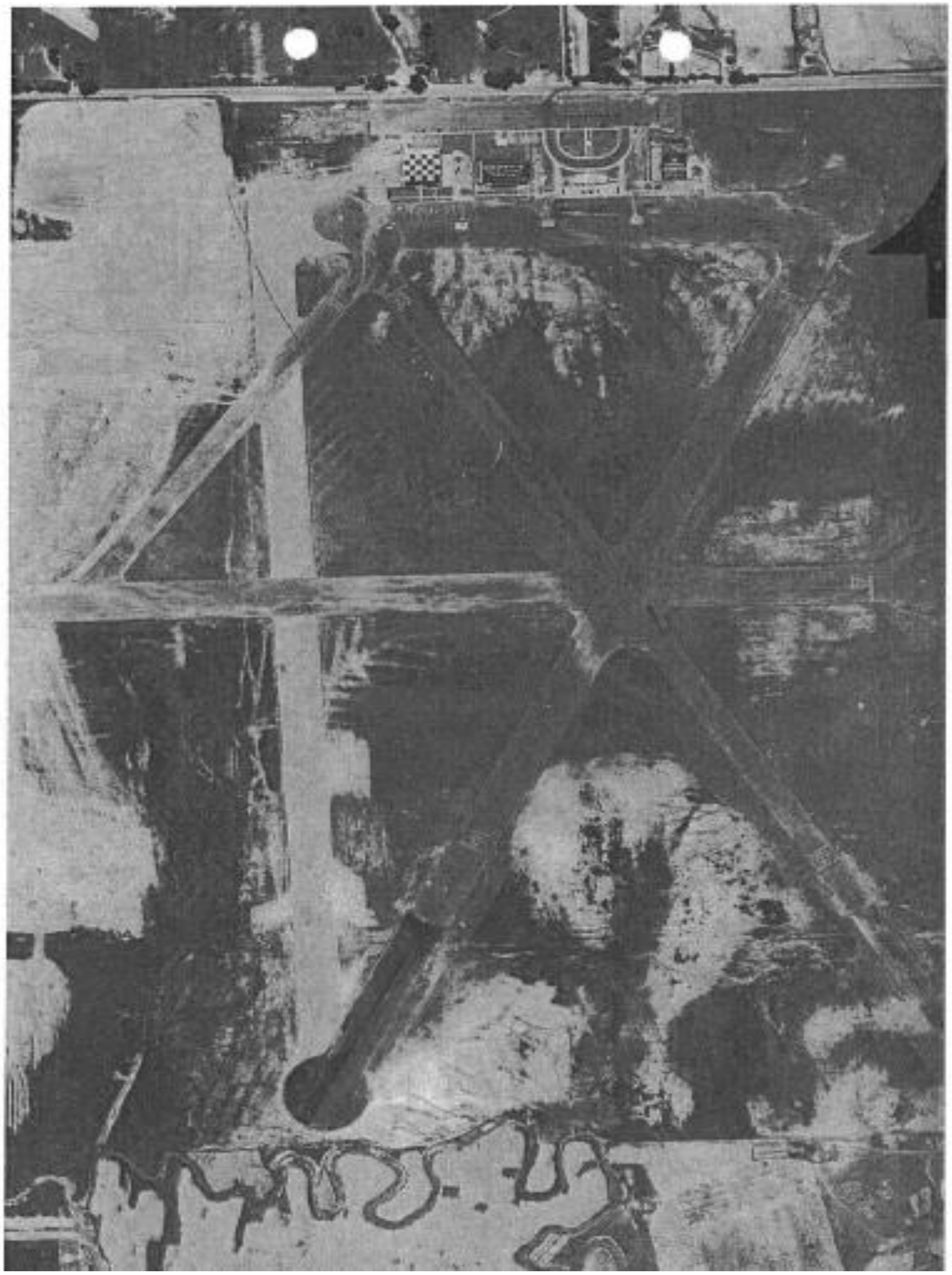

Figure 4.14 Aerial view of airport runway in 1940 (Womack 2003).

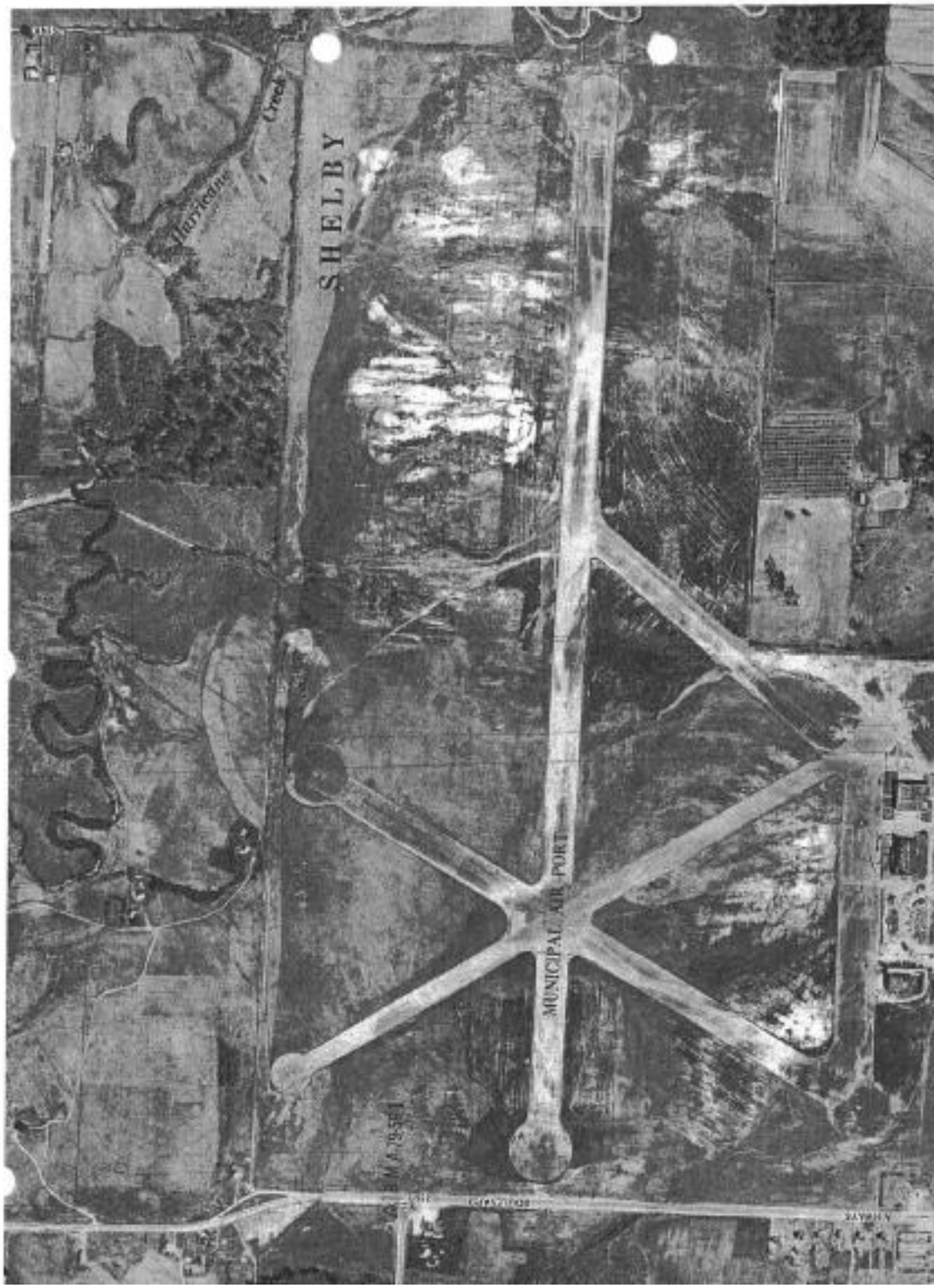

Figure 4.15 Aerial view of runway in 1938 (Womack 2003).

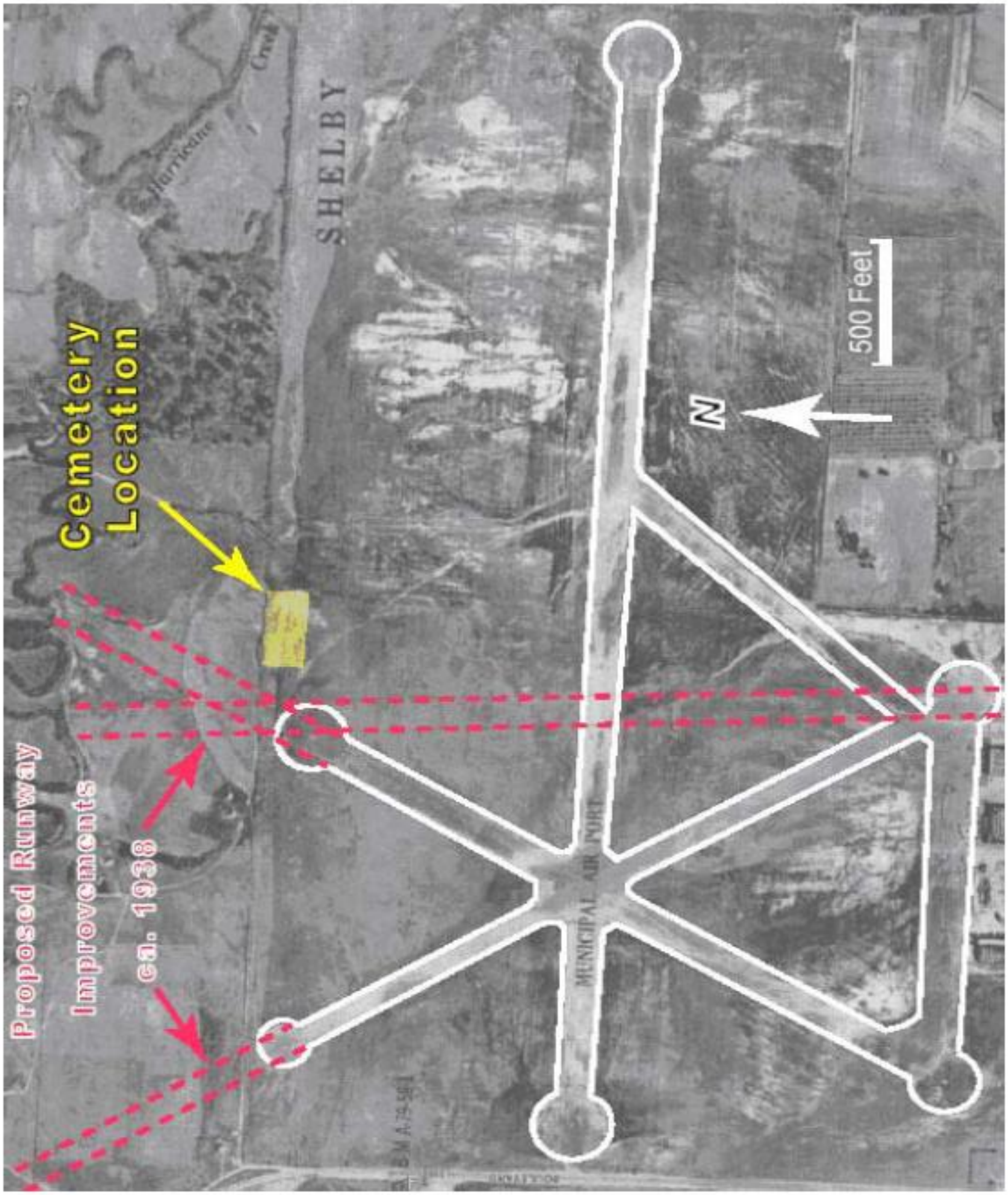

Figure 4.16 Map of proposed runway construction at the Memphis Municipal Airport (Wilson 2005).

Figure 4.17 East view of probable grave sites (Womack 2003).

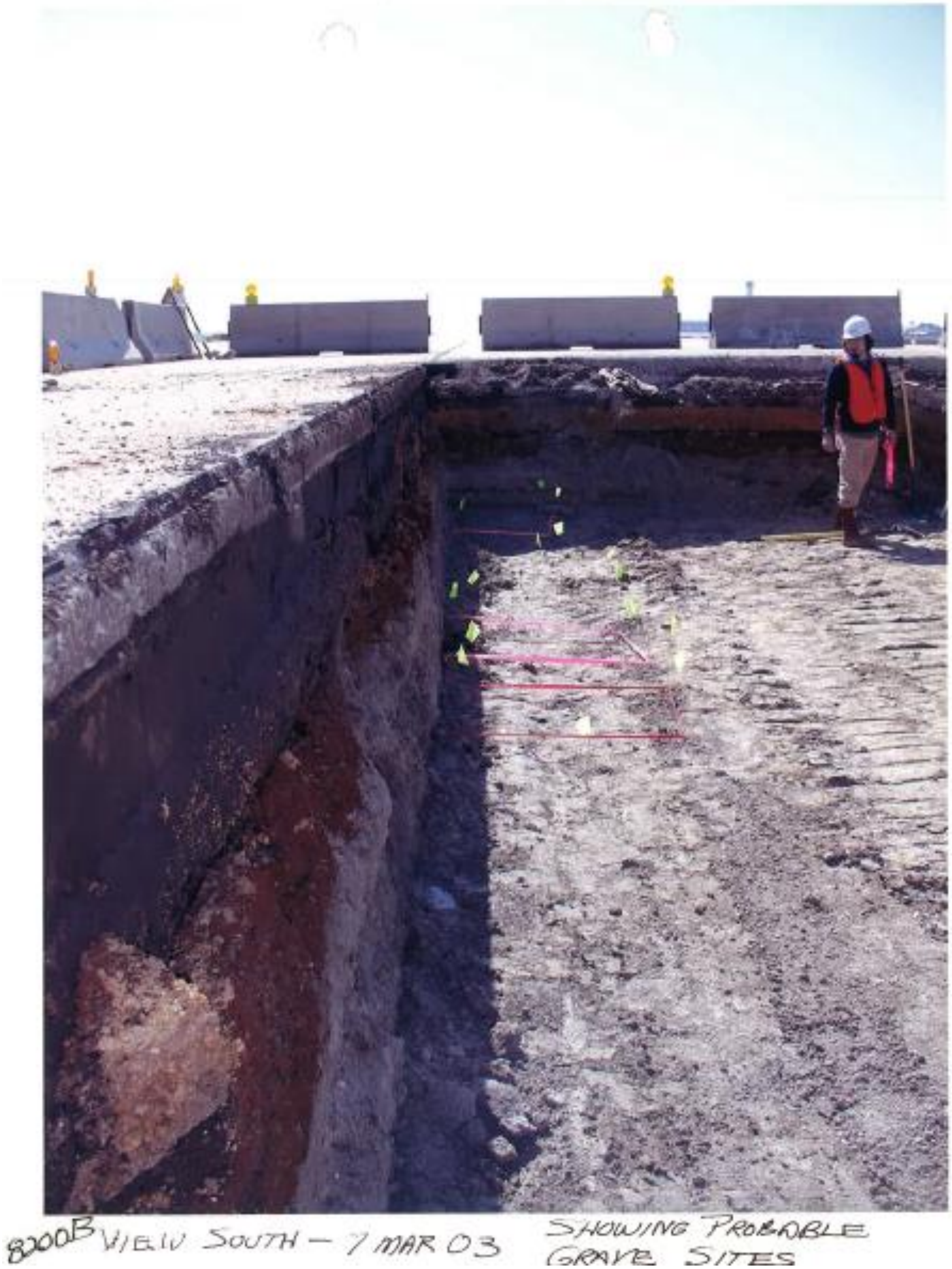

Figure 4.18 Southern view of probable grave sites (Womack 2003).

Figure 4.19 Field photograph of Frankie LeFlore's tombstone (Weaver 1998).

Figure 4.20 Burial 29, a 10-12 year old sub-adult, exhibiting a lateral curvature of the vertebral column (Wilson 2005).

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MATERIALS AND METHODS

Materials

The materials used to conduct this research are divided into two parts: analysis of African American populations and establishing a methodology to evaluate cementum (see table 5.1). The primary are dental sources are historic African American, modern African American, and modern White mandibular canines including five male and five female thin sections selected from Cedar Grove Baptist Church Cemetery (Texarkana, AR) and the First African Baptist Church Cemetery (Philadelphia, PA). Just five male thin sections were selected from Providence Baptist Church Cemetery, Memphis (TN). All slides were originally collected, produced, and furnished by Marks as a sample from his doctoral thesis “Dental Enamel Microdefects as Indicators of Childhood Morbidity Among Historic African Americans,” at the University of Tennessee (1993).

The modern tooth samples were acquired through the Department of General Dentistry, at the University of Tennessee Medical Center Knoxville (see table 5.2). These teeth were removed as a result of routine dental procedures. To establish a methodology, these samples were used to establish an adequate thickness and staining technique for best observation (see figure 5.1).

Table 5.1 Population Information.

CEMETARY	BURIAL NUMBER	SLIDE NUMBER	ID NUMBER	SEX	AGE	TOOTH NUMBER
FABC						
	13800	138	5329	F	33	22
	09900	99	8890	F	44	22
	00000	100	1137	F	21	22
	11400	114	7320	F	40	22
	12300	123	2599	F	15	22
	10100	101	5380	M	46	22
	03200	32	2695	M	51	27
	03300	33	6919	M	31	22
	07700	77	6859	M	39	22
	11500	115	5615	M	58	27
CEDAR GROVE						
	00103	91650	F103	F	25	22
	00081	90657	F81	F	22	22
	00065	94362	F65	F	27	27
	00014	93376	F14	F	32	22
	00021	94742	F21	F	55	22
	00061	96743	M61	M	44.5	22

Table 5.1 Continued

CEMETARY	BURIAL NUMBER	SLIDE NUMBER	ID NUMBER	SEX	AGE	TOOTH NUMBER
CEDAR GROVE						
	00055	90366	M55	M	17	22
	00010	91009	M10	M	27	22
	00024	98052	M24	M	37	22
	00096	91403	M96	M	47	22
PROVIDENCE						
	00008	1-2	1	M	50	22
	00016	3-4	2	M	40	27
	00012	8-9	4	M	40	22
	00028	10-11	5	M	35	22
	00019	12	6	M	60	27

Thin sections of the teeth were fabricated utilizing coper wire, 22 x 30 mm Peel-A-Way disposable molds by Polysciences Inc. (Warrington, PA), Buehler's EpoThin™ 2 Epoxy Resin(20-3440-128) and EpoThin™ 2 hardener(20-3432-064), a diamond blade Buehler Isomet Slow Speed Saw, gel super glue, microscopy slides, and a grinder with 600 C and 1500 Micro Fine 3M paper were used. The slides were labeled using a diamond tip scribe (see figures 5.2 through 5.4).

Slides were stained with the Hematoxylin and Eosin Stain Kit by TissuePro Technology. The staining process also included 70% isopropyl alcohol, tap and distilled water, and one normal solution of hydrochloric acid.

Microscopic evaluation was performed using a Leica DMRX light microscope, Sony DXC-S500 IEEE1394 Color Digital Camera, Image-Pro Express software, Zeiss Auriga Crossbeam FIB/scanning electron microscope, and a SPI SPUTTER/Carbon Coater at the Joint Institute for Advanced Material.

For part two, four single rooted teeth were used, ultimately resulting in a total of 6 slides. The materials used to embed, create thin sections, mount ground, and view slides were duplicated from part one. Additional materials used in part two included Xylol Xylene by Klean Strip and a micrometer.

Table 5.2 Cementum Methodology Study Slide Demographics.

SLIDE NUMBER	INITIAL SLIDE THICKNESS IN INCHES	INITIAL SLIDE THICKNESS IN MICRONS
1	.00860	218.44
2	.01450	368.3
3	.01615	410.21
4	.00140	35.56
5	.01360	345.44
6	.07775	1974.85

Figure 5.1 Photograph of embedded teeth used to take transverse thin sections, by Kortney Dewayne Powell.

Methods

Sample Collection

The collection of thin sections was first organized, examined, and documented. From this initial evaluation, sample sizes were established. For each population, 5 female and 5 male thin sections were selected when available. All thin sections evaluated were permanent maxillary canines of individuals over an evenly distributed age range. They were then analyzed for quality and noted for repair. To repair the slides, super glue was added to the epoxy resin thin sections and remounted onto their slides. Afterwards, the slides were grounded.

For the modern reference samples, three White teeth and one African American tooth were embedded in an epoxy resin solution which stabilized the tooth for microscopic examination. This procedure is a modification of the Marks, Rose and Davenport method (Marks, Rose et al. 1996).

The Embedding Process

First, teeth were wrapped around the cementoenamel junction, in copper wire, forming a butterfly pattern to serve as a stand. The copper wire and suspended tooth were the placed in 22 x 30 mm Peel-A-Way disposable molds, by Polysciences Inc. (Warrington, PA), and secured using superglue. Molds were then filled with the embedding medium and left at room temperature for twenty-four hours to cure.

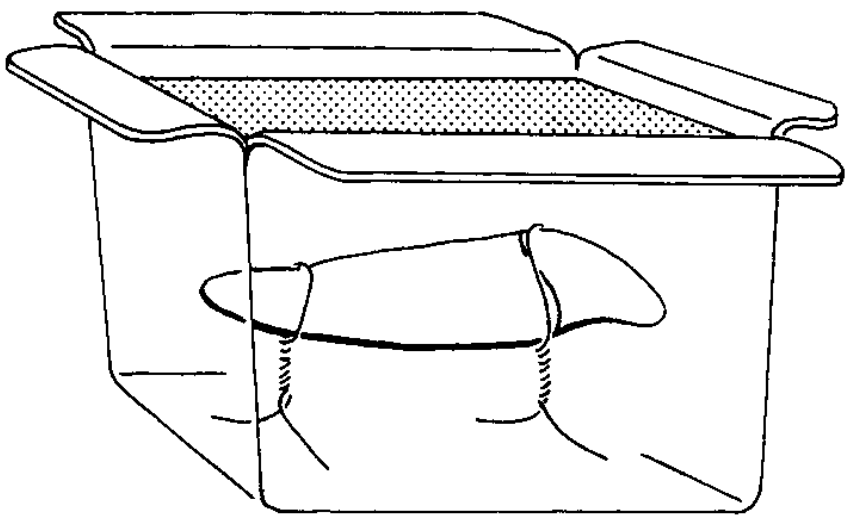

Figure 5.2 A tooth suspended within a mold using copper transformer wire (Marks, Rose et al. 1996).

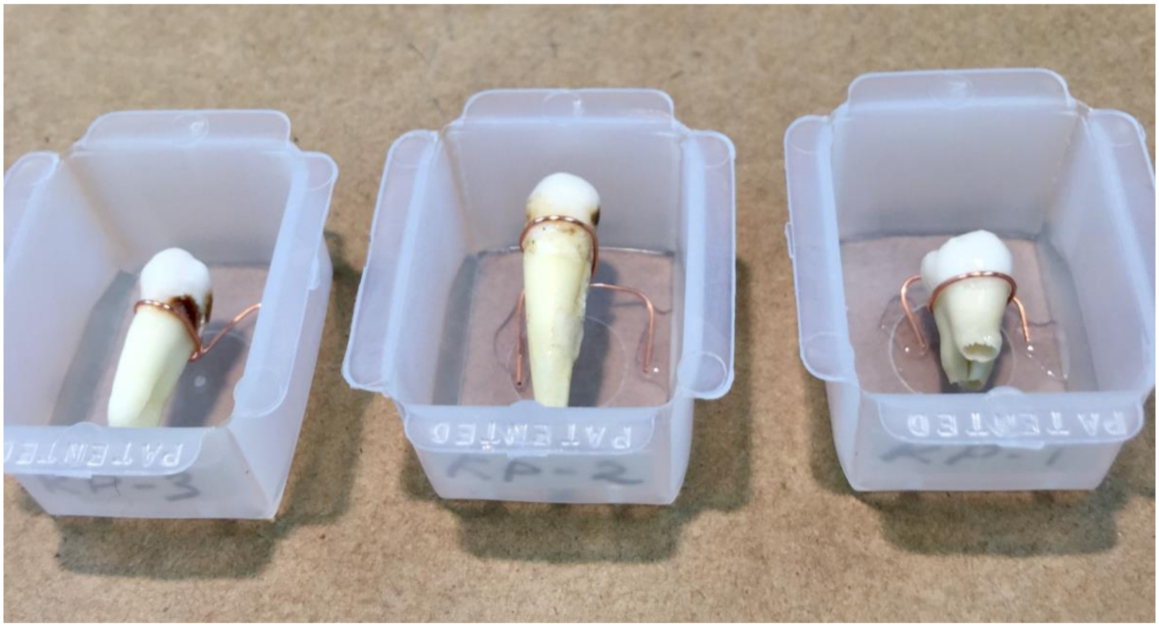

Figure 5.3 Photograph of teeth being prepared of embedding, wrapped in copper wire and placed in molding trays.

Figure 5.4 Photograph of teeth in molding trays, filled epoxy.

Creating Thin Sections

Second, the cured blocks were removed from their molds for in preparation for thin sectioning. The sectioning involved the use of a diamond blade Buehler Isomet Slow Speed Saw. Cured blocks were mounted, and the saw positioned to create 15 mm thick sections, off centering the tooth longitudinally and labiolingually for the first cut. Calibrated on a scale of 1-10, the saw speed was held at 7.5 with a pressured weight of 70 g. After the first cut, the cured block is cleaned with 70% isopropyl alcohol to remove the oil that cools the saw blade. Then a slide is attached to the block with superglue, the saw is positioned back to the center of the tooth, for a second cut. This step is then repeated to obtain a second copy. Completed slides were then etched with a diamond engraving pencil for identification of the thin section (see figure 5.5).

The Grinding Process

Third, thin sections went through a grinding process to smooth edges created by the saw. This was performed with a grinder using 3M 600 and 1500 microfine grinding paper and water. To grind, an appropriately-sized slide holder must be used. Once the turntables are spinning, the sandpaper is moistened, and the slide is held gently over the sandpaper; Maneuvering the slide in a zig-zag motion.

Figure 5.5 Photograph of longitudinal thin section being made.

Hematoxylin and Eosin Staining

Fourth, the slides were stained with a hematoxylin and eosin staining kit. This process includes rehydration in 70% isopropyl alcohol to be for three minutes, then in distilled water for one minute. They were next stained with the hematoxylin for ten-minutes and rinsed with tap water. The slides were then etched in hydrochloric acid for twenty-five seconds and rinsed again in tap water. The slides were next stained with eosin for two minutes, dehydrated in isopropyl alcohol for three minutes, and allowed to dry.

Light Microscopy

After staining, slides where examined using the *Leica DMRX* light microscope, *Leica MZ6* dissecting-scope, *Leica KL1500* LCD light source, *Sony DXC-S500 IEEE1394* Color Digital Camera, and *Image-Pro Express* software. Viewing on the light microscope was done using a magnification of 50x-400x, but all results were documented at 200x. Viewing on the dissecting scope was done using 10x.

Scanning Electron Microscopy

In preparation for SEM, copper tape was added to slides so it is not isolated when electrons are aimed at the stage. Afterwards, they were taken to the sputter coater, radiated in argon for twenty seconds, to form a continuous conductive film (see figure 5.6). Slides were then loaded into the Zeiss Auriga Crossbeam FIB/scanning electron microscope's stage chamber, pumped with nitrogen, and then beamed for evaluation (see figure 5.7).

Creating A Method to Best Analyze Cementum

To establish a best practice in observing cementum, there was multiple deviations from the methods above. The first four teeth were sectioned within the apical-third of the root, transversely, opposing the traditional longitudinal cut (see figures 5.8-5.9). After slides were cut and mounted, they were ground to 5 varying thicknesses ranging from 37-410 microns. Slides were then analyzed on the light microscope at varying magnifications, ultimately 200x was the chosen standard of best practice.

The speed of the diamond blade saw was adjusted to level 3 for slide number 5. After the section was cut and ground, it was etched in the hydrochloric acid for 5 seconds before being observed on the light microscope, at 20x magnification.

The speed of the diamond blade saw was adjusted, again, to level 10 for slide number 6. The slide was also etched for 5 seconds in hydrochloric acid and measured for slide thickness using the micrometer. After observation, the slide was dehydrated in alcohol for 2min, and defilmed in xylene for 30 seconds.

The slide was then observed under fluorescent lighting, ultimately at 200x magnification. After observation, the slide was ground down to a (.04435in) thickness.

In order to establish the proper staining technique to observe cementum, slides were taken to the University of Tennessee's College of Veterinary Medicine. There, thin sections were stained using the Von Kossa method as follows: hydrated to distilled water, rinsed in Millipore water, place in 5% Silver Nitrate solution for 60 minutes, rinsed in Millipore water, placed in 5% Sodium Thiosulfate for 3 minutes, rinsed in Millipore water, counterstained in Nuclear Fast Red for 3 minutes, dehydrated, and then cleared.

Figure 5.6 Photograph of thin section being coated in gold by sputter coater.

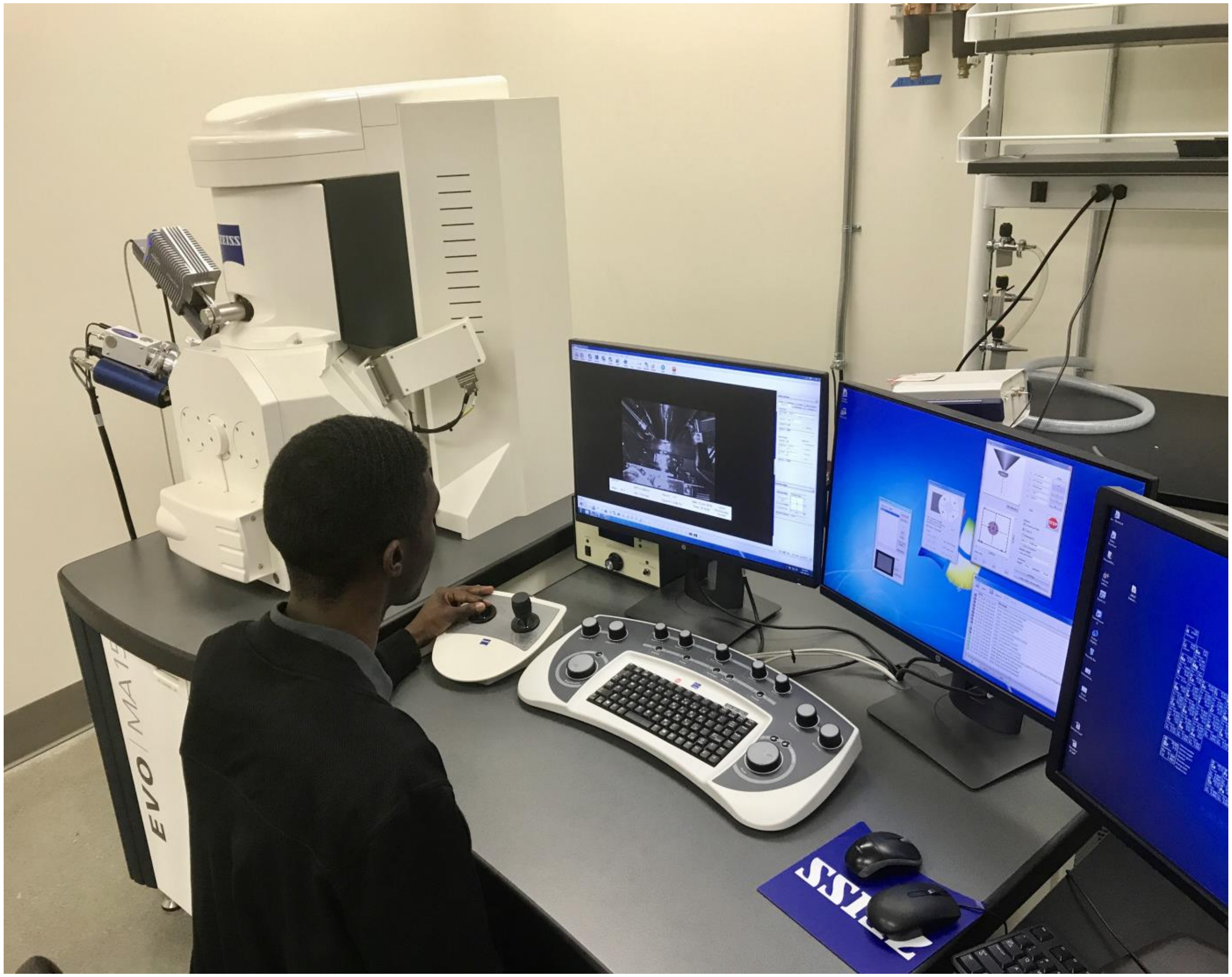

Figure 5.7 Photograph of slides being prepared and positioned within the scanning electron microscope.

Once the slide was ground, it was then etched for 10 seconds in the hydrochloric acid. The slide was ultimately ground down to (.03835 in). Afterwards, the slide was observed the H&E staining method was followed as described: cleared in xylene for 6 minutes, dehydrated in alcohol for 9 minutes, and then preceded the with the steps mentioned above.

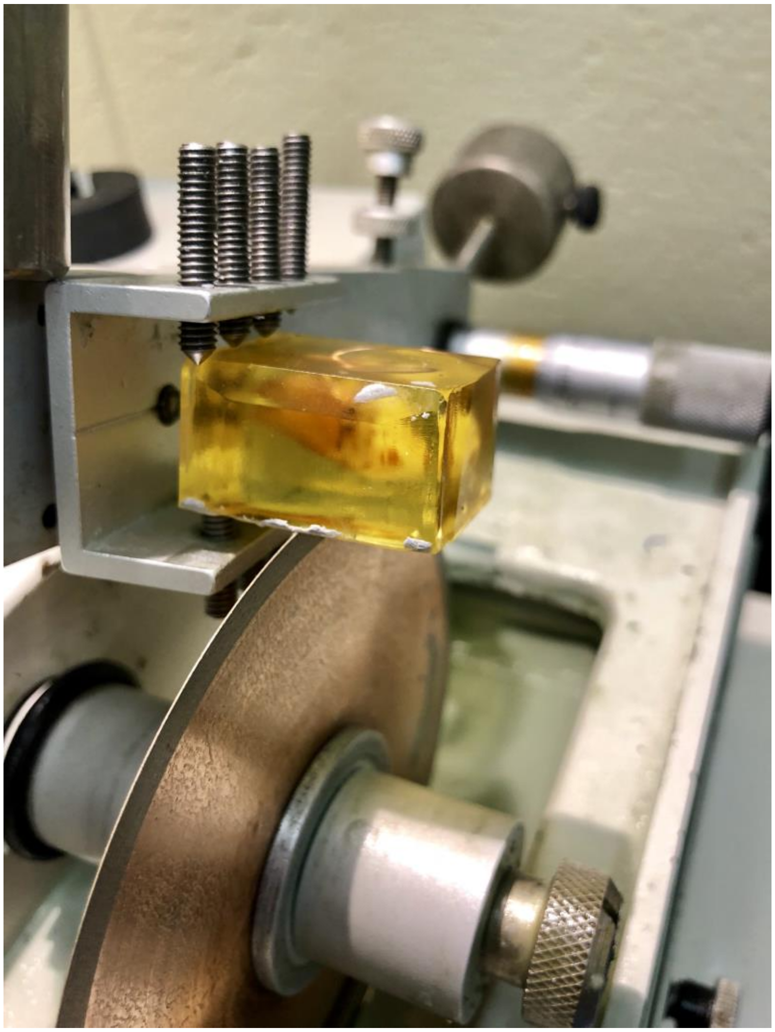

Figure 5.8 Photograph of embedded tooth being transversely cut.

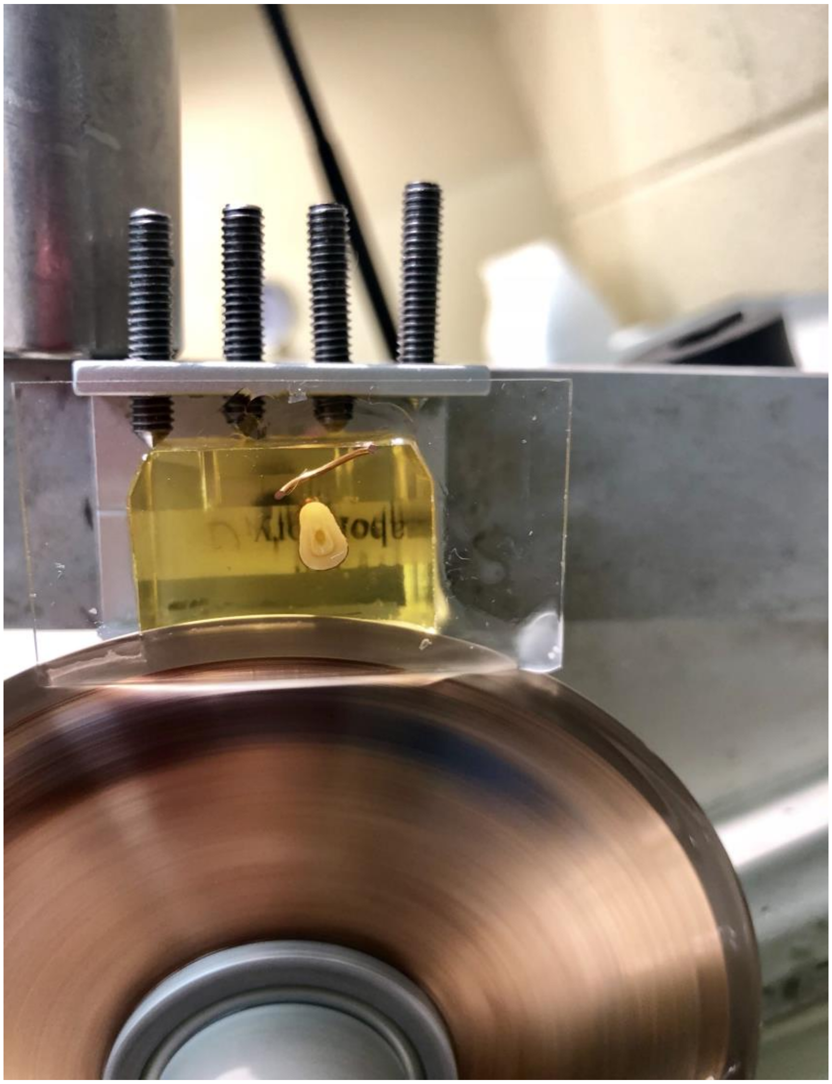

Figure 5.9 Photograph of the apical-third of the root being mounted to a slide and cut.

RESULTS AND DISCUSSION

Banding is visibly present in the historic African-American populations as seen in figures 6.1-6.4, 6.7-6.10, and 6.13-6.28. This banding occurs in reasonably defined alternating increments. Based on the results, age can be estimated using these samples. The cementum annuli are made legible by progressively enhancing the microscopic technology with digital imaging software. This can be best seen within the Cedar Grove samples, figures 6.13-6.28.

There was not a positive change in sample clarity from the Providence Baptist Church Cemetery, Figures 6.11 and 6.12. As the fluorescent filter was added to the light microscope it did not have a positive effect. These two samples lack the potential for further study. Additionally, the modern African-American sample, figures 6.29 and 6.30 are of poor quality when viewed with the light microscope. Visibility of the annuli was increased with the use of scanning electron microscopy and further enhanced using Photoshop.

Figures 6.33 and 6.34, the transversely cut sample, possessed great initial potential. As all of the other slides underwent staining, it was only treated with xylene. Photoshop improved its quality; but did not provide the same quality of visualization as the samples from Cedar Grove.

The poor quality of figures 6.11 and 6.11 could be caused by sample aging, demarked by the cracks caused by shrinkage within the epoxy. Additionally, the vertical lines made across the samples, or ‘chatter lines’ were created by the saw in the process of creating the thin sections, this could also cause slide quality to decline. This can be seen in great detail on transversely cut sample, figures 6.33 and 6.34.

FABC 56151

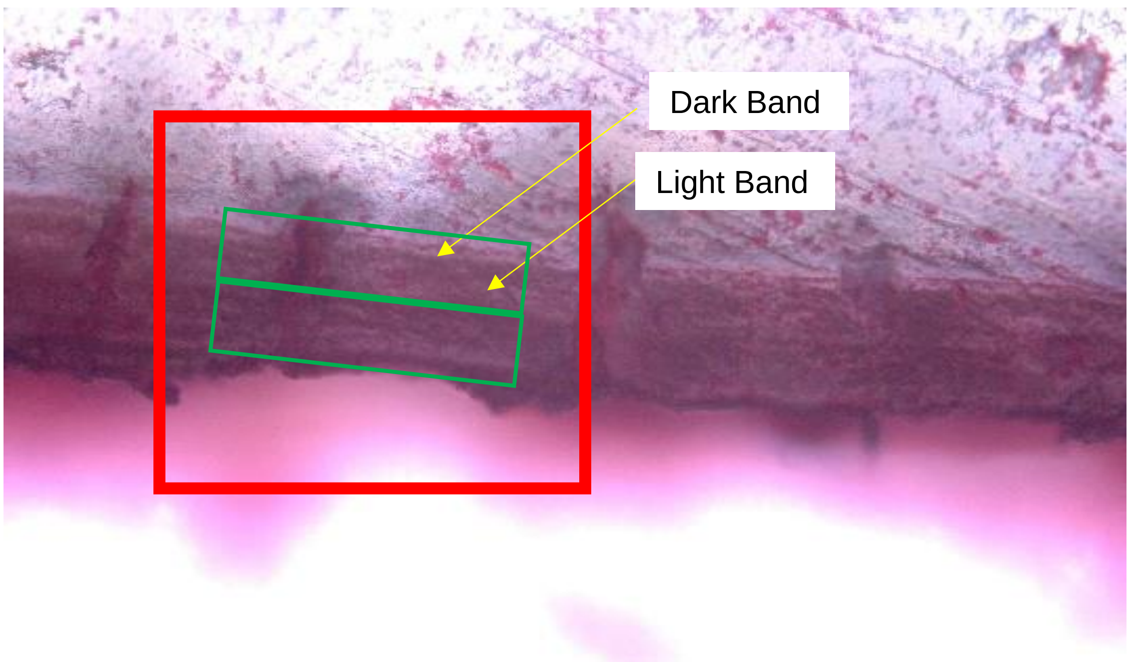

Figure 6.1 Micrograph of FABC slide #56151 under regular light microscopy at 200x magnification.

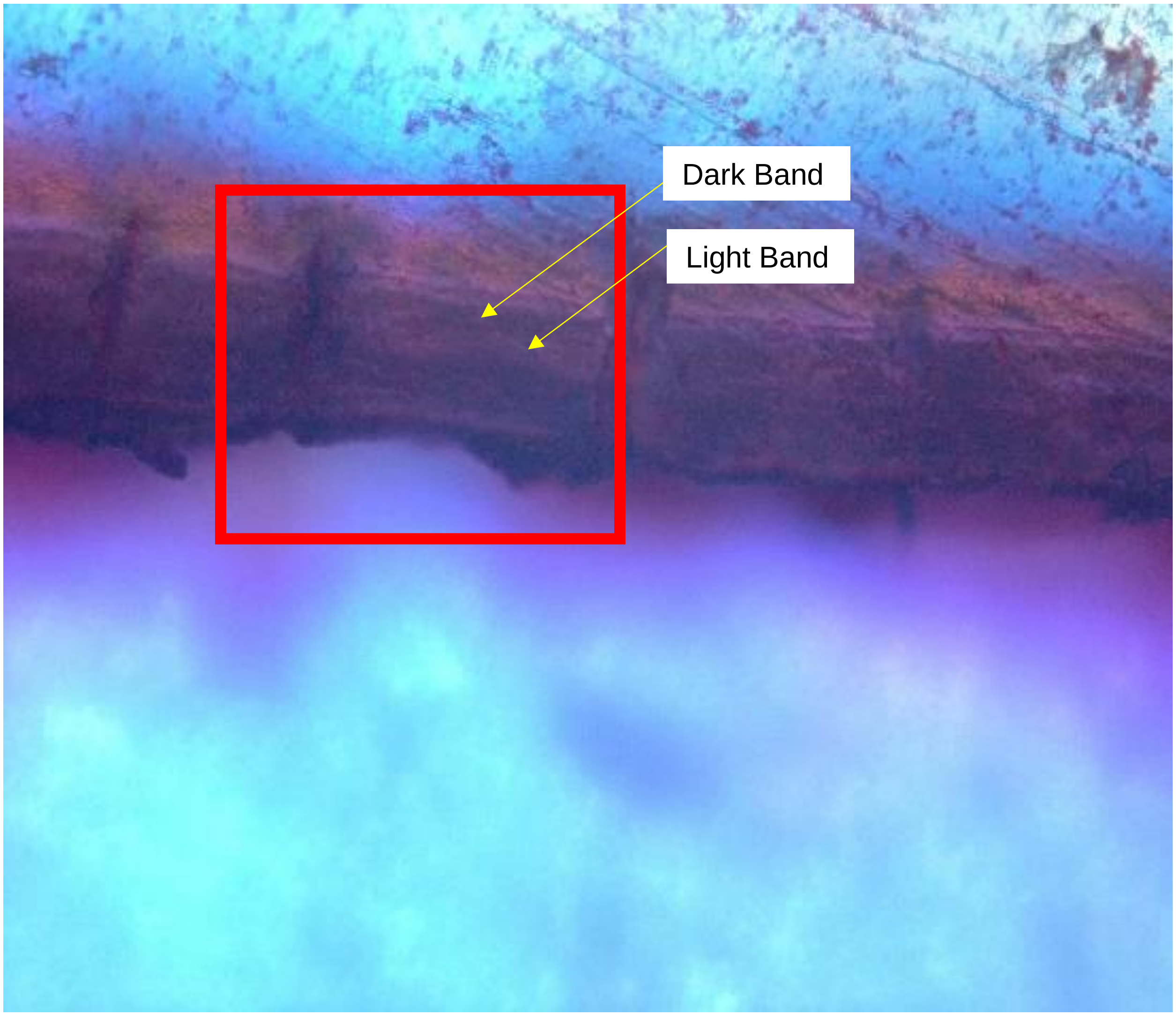

Figure 6.2 Micrograph of FABC slide #56151 under regular light microscopy and a fluorescent filter, at 200x magnification.

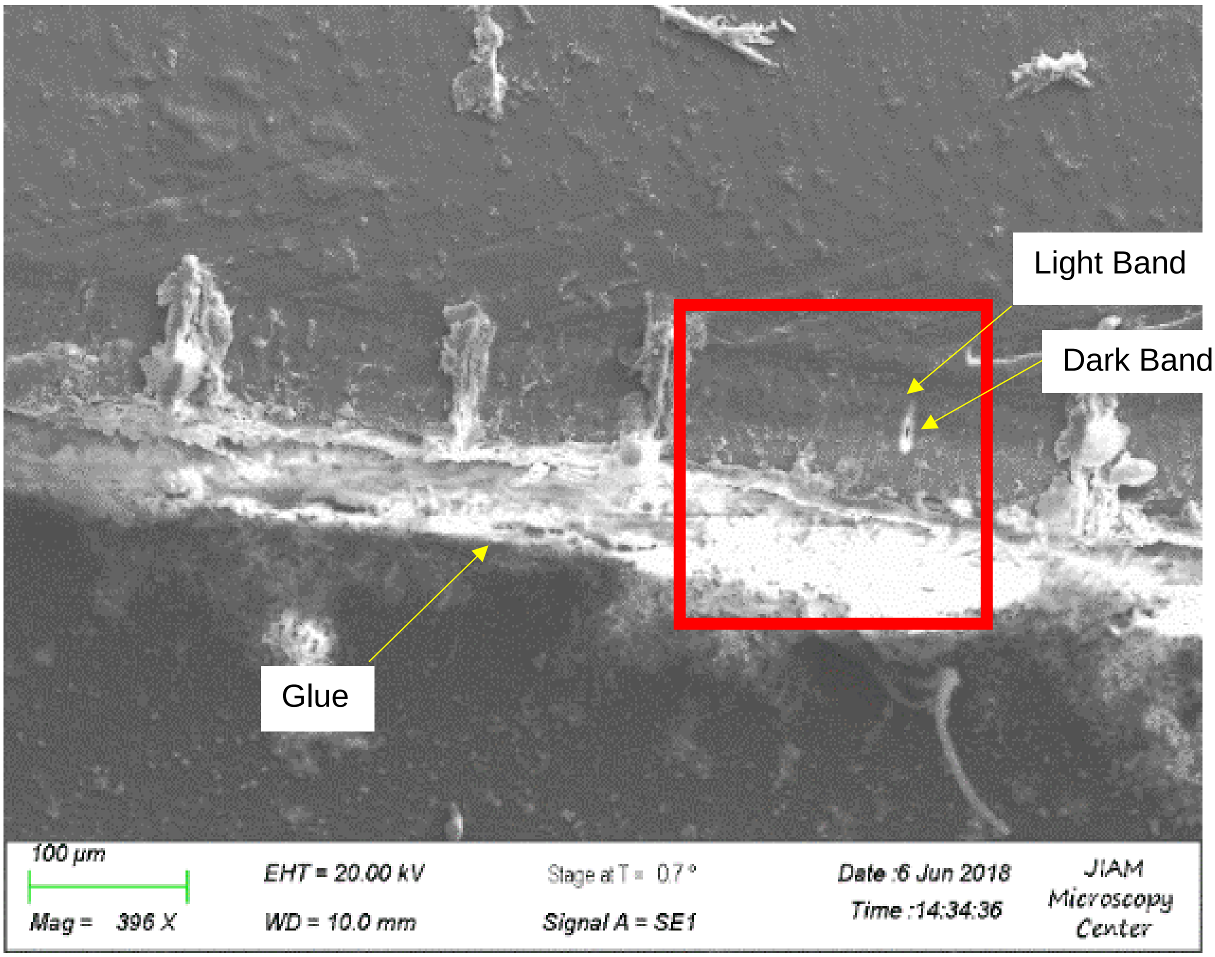

Figure 6.3 Micrograph of FABC slide #56151 under scanning elcectron microscopy at 396x magnification.

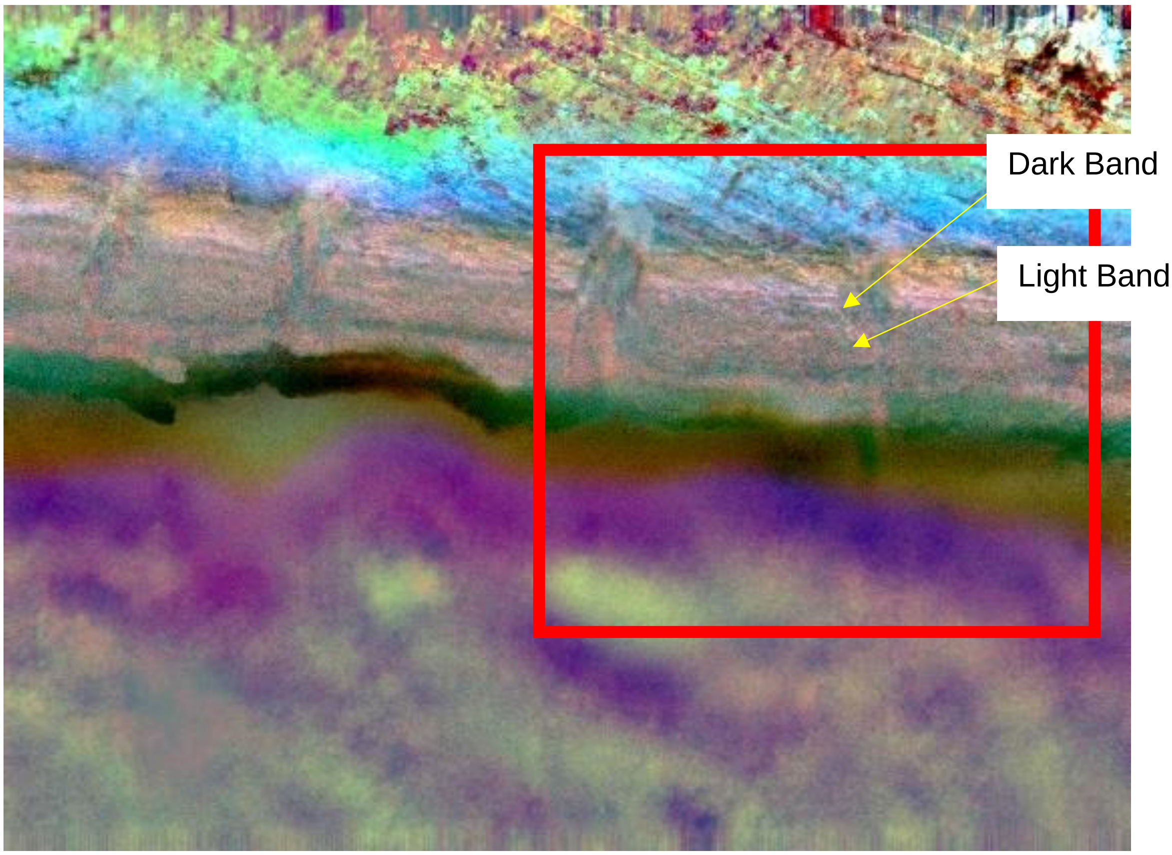

Figure 6.4 Micrograph of FABC slide #56151 under regular light microscopy at 200x magnification, and digitally enhanced with Adobe Photoshop CC Embossing Tool.

FABC 68591

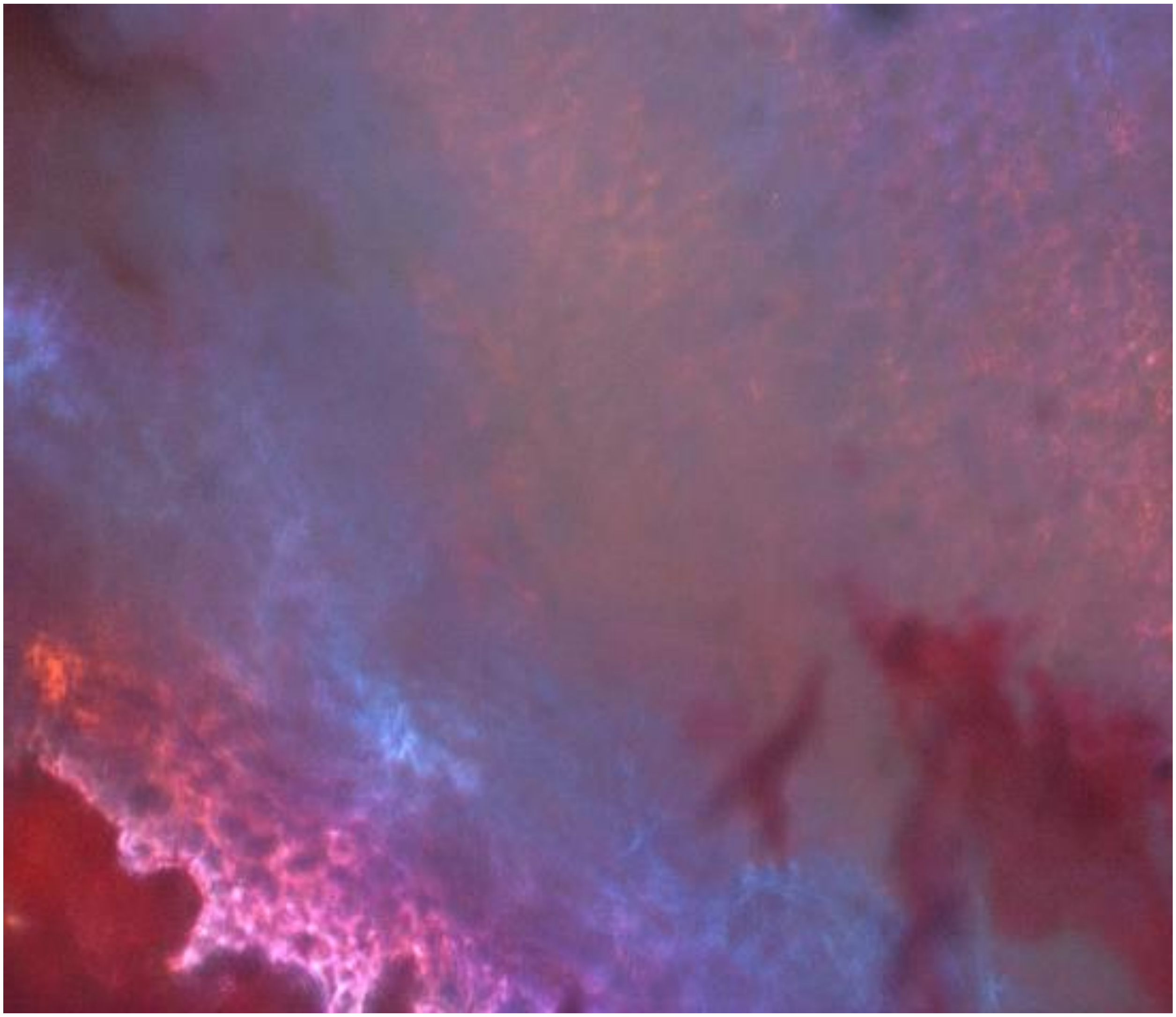

Figure 6.5 Micrograph of lacunae on FABC slide #53741 under regular light microscopy and a fluorescent filter, at 200x magnification.

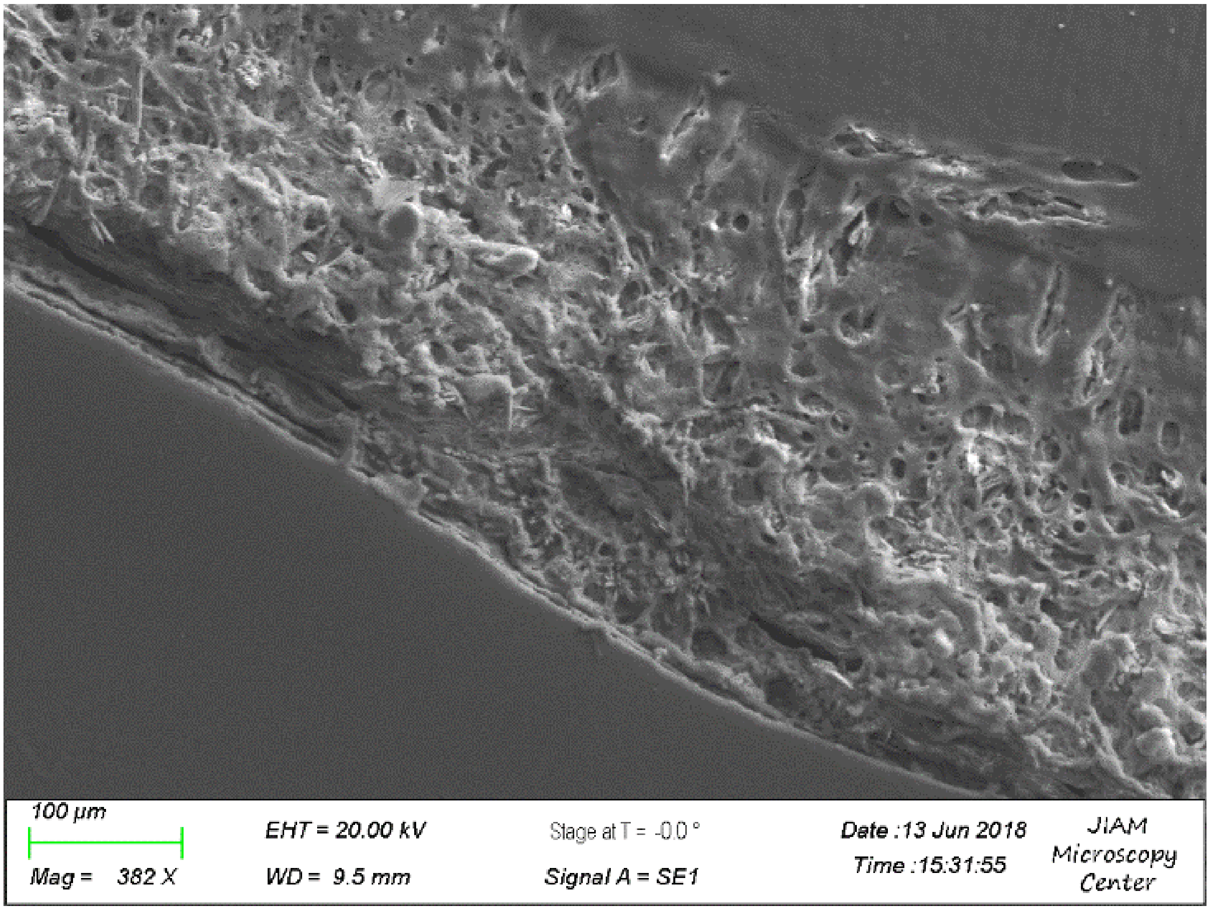

Figure 6.6 Micrograph of lacunae on FABC slide #53741 under scanning elcectron microscopy at 382x magnification.

PROVIDENCE (FEDEX) 22_22

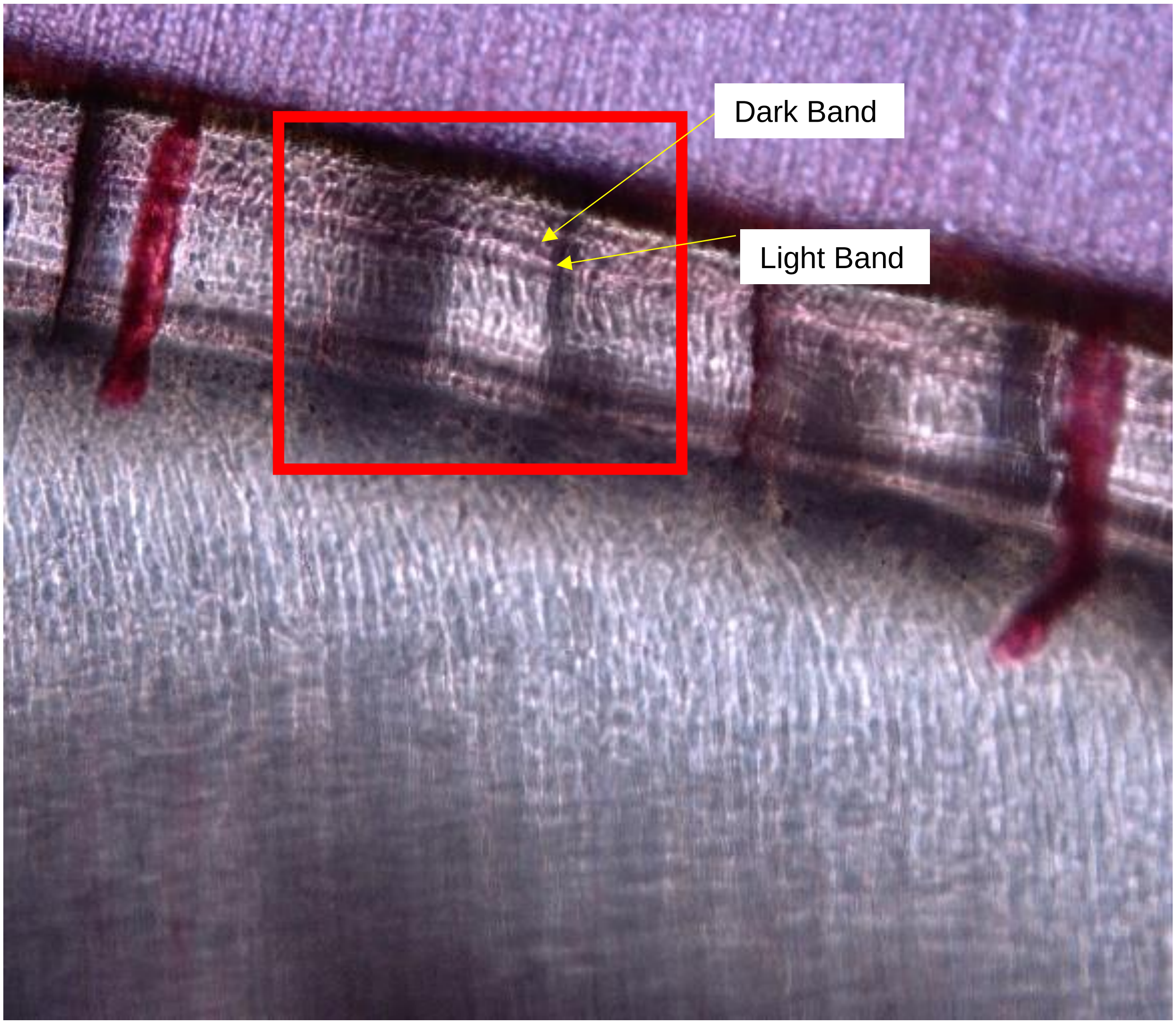

Figure 6.7 Micrograph of Fedex slide #22_22 under regular light microscopy at 200x magnification.

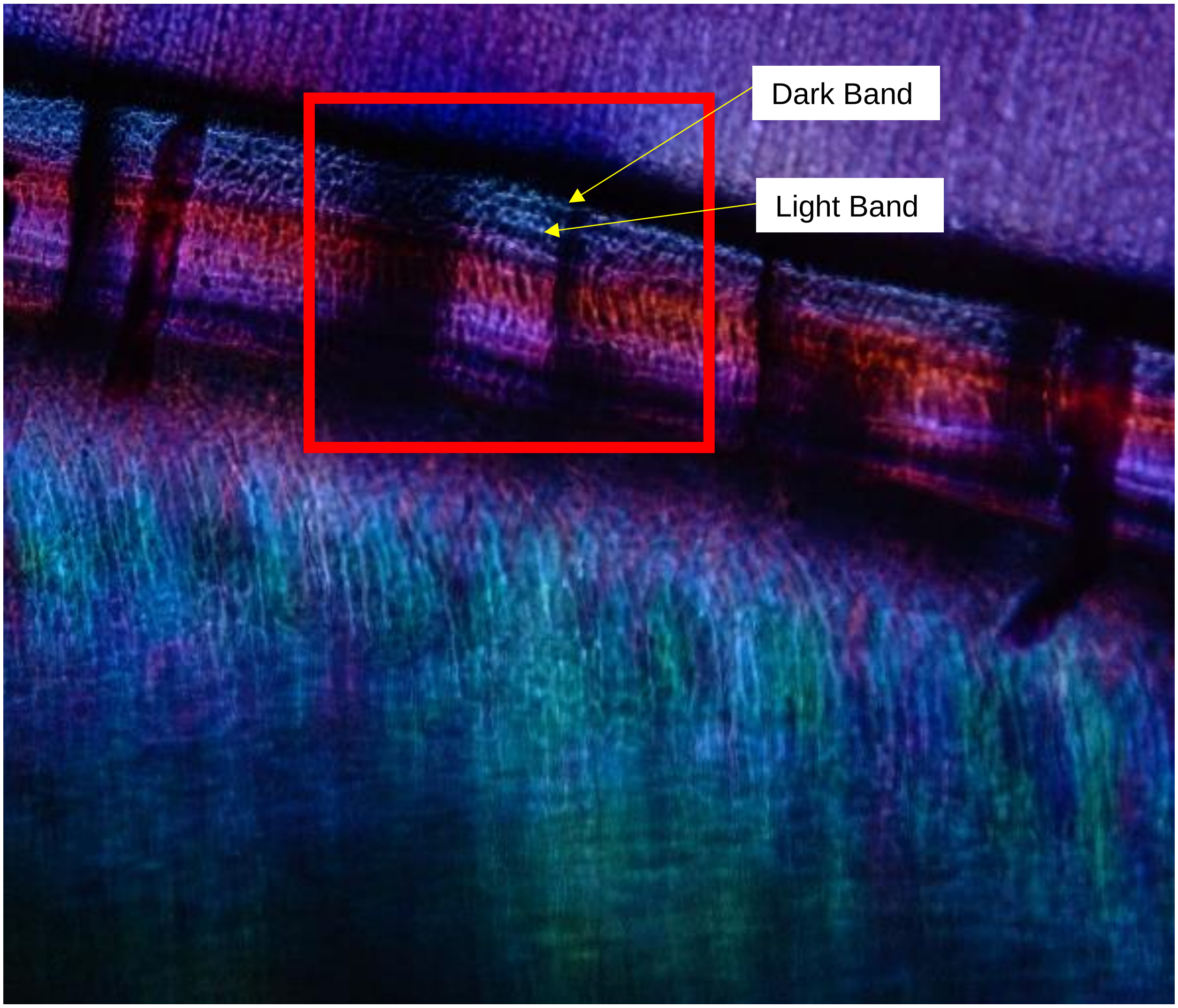

Figure 6.8 Micrograph of Fedex slide #22_22 under regular light microscopy and a fluorescent filter, at 200x magnification.

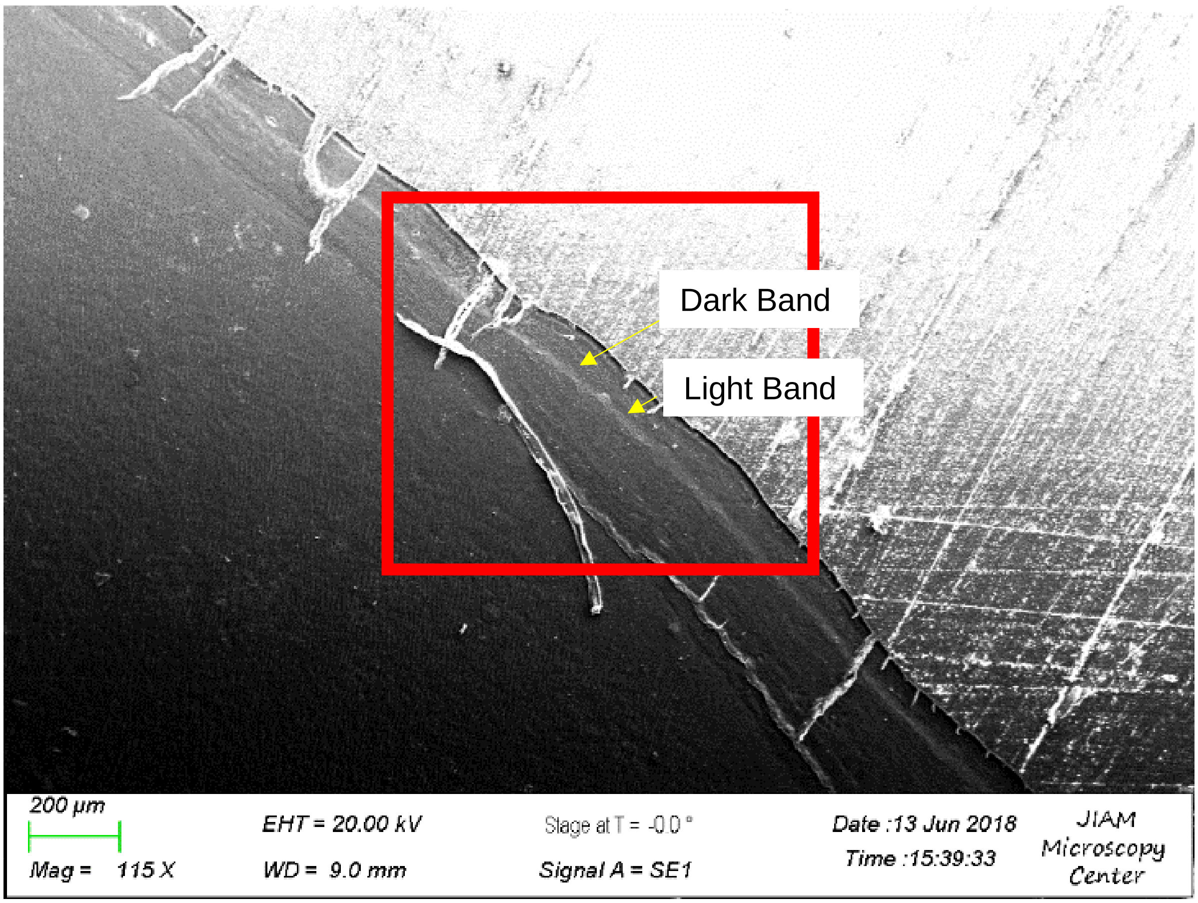

Figure 6.9 Micrograph of Fedex slide #22_22 under scanning elcectron microscopy at 115x magnification.

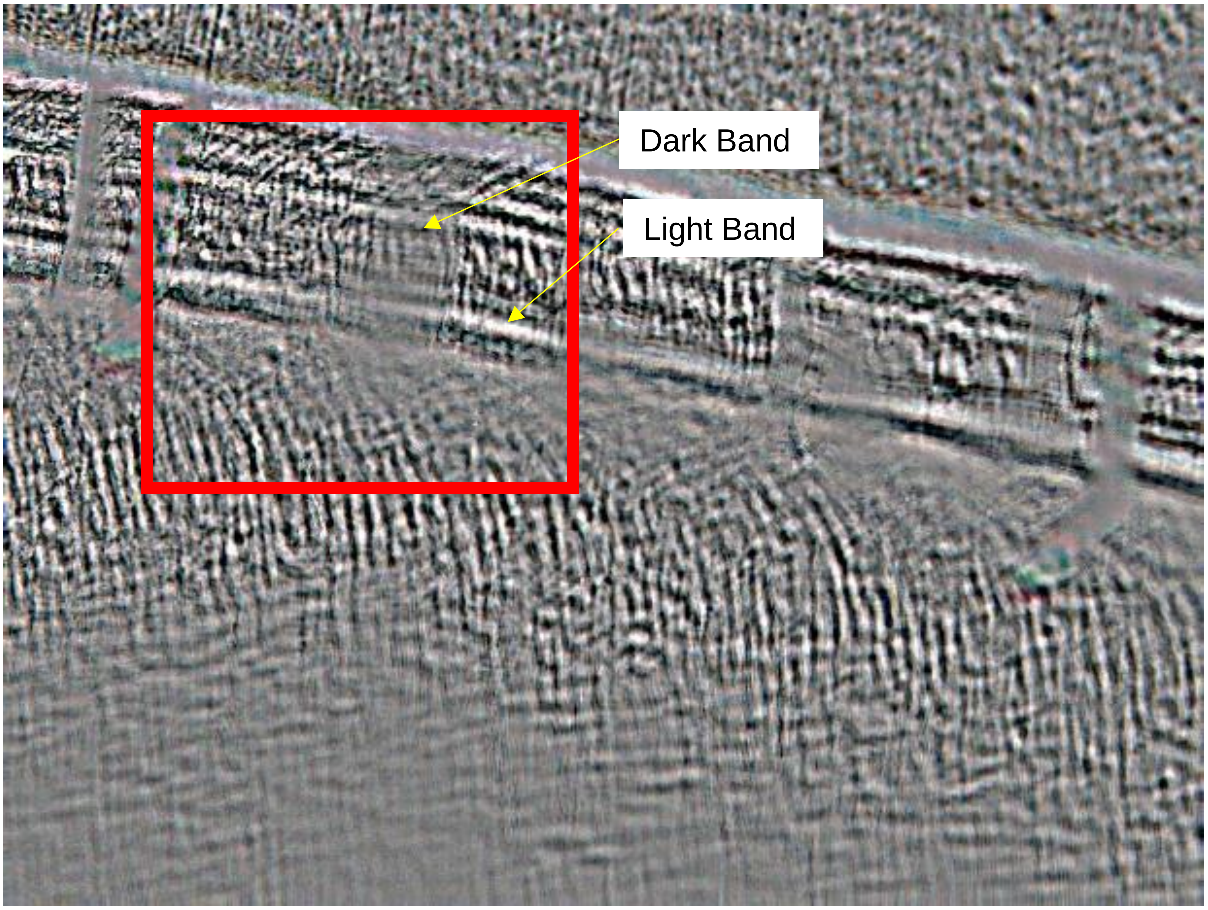

Figure 6.10 Micrograph of Fedex slide #22_22 under regular light microscopy at 200x magnification, and digitally enhanced with Adobe Photoshop CC Embossing Tool.

PROVIDENCE (FEDEX) 22_22B

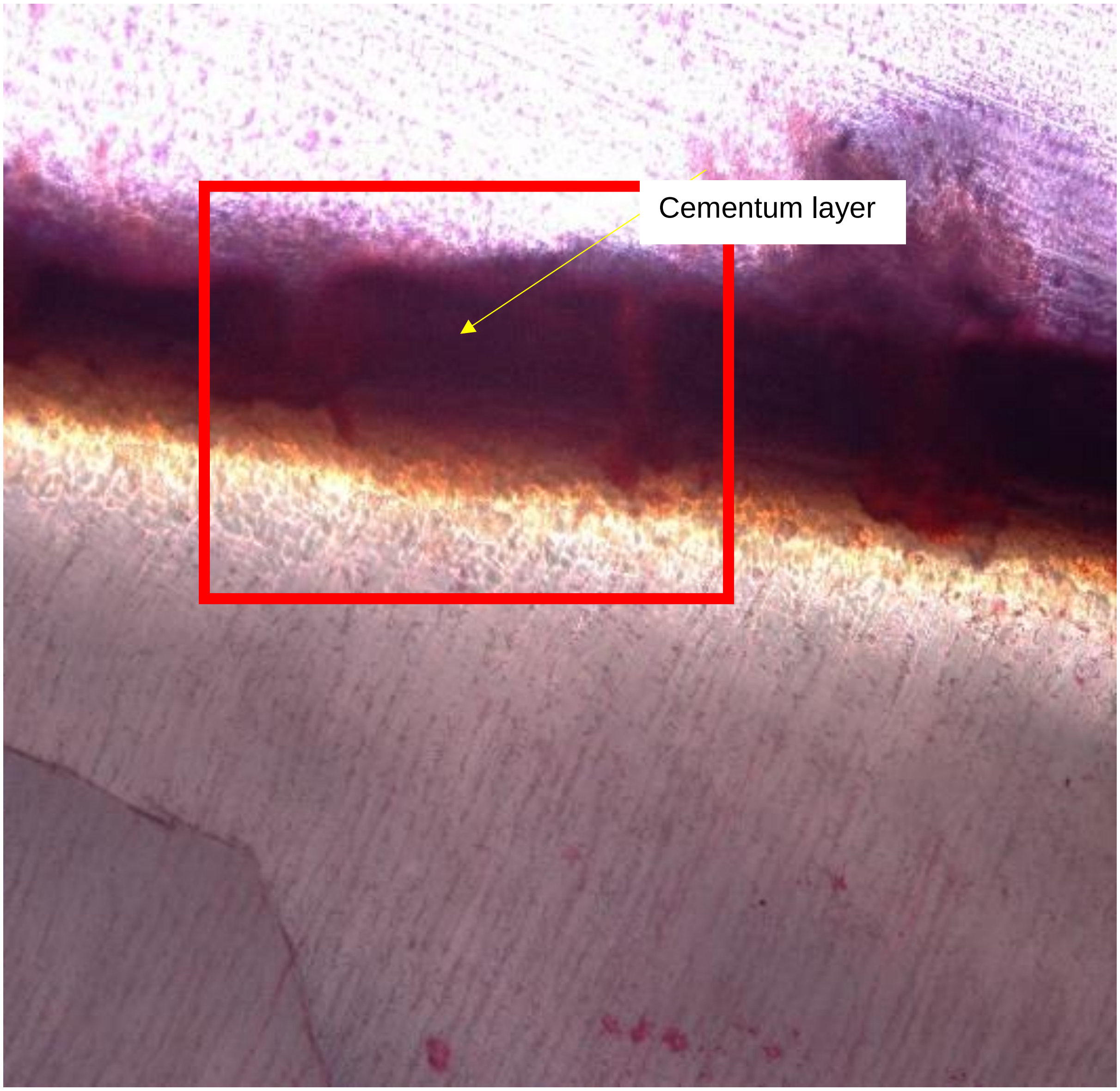

Figure 6.11 Micrograph of Fedex slide #22_22B under regular light microscopy at 200x magnification.

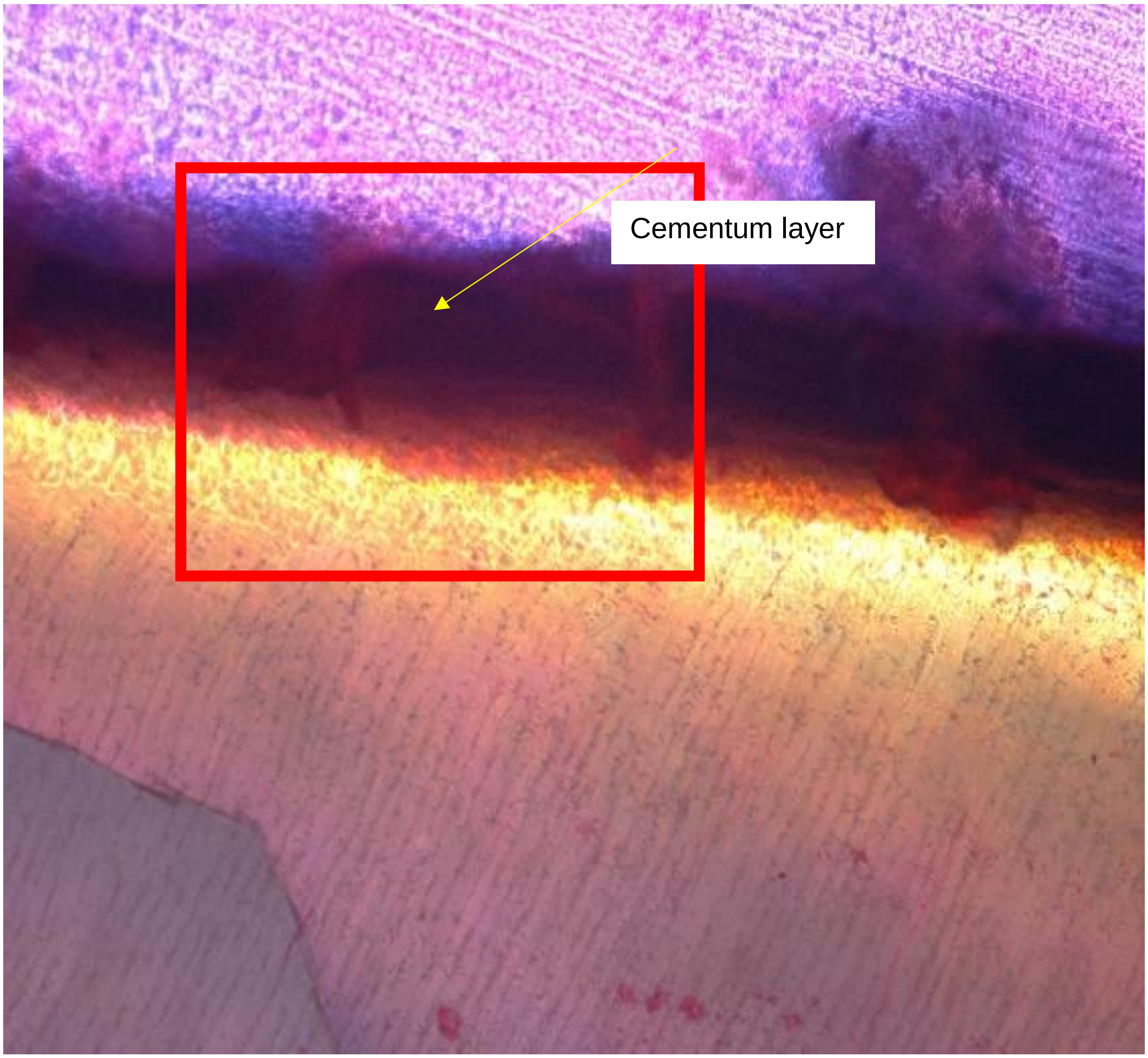

Figure 6.12 Micrograph of Fedex slide #22_22B under regular light microscopy and a fluorescent filter, at 200x magnification.

CEDAR GROVE 90336B

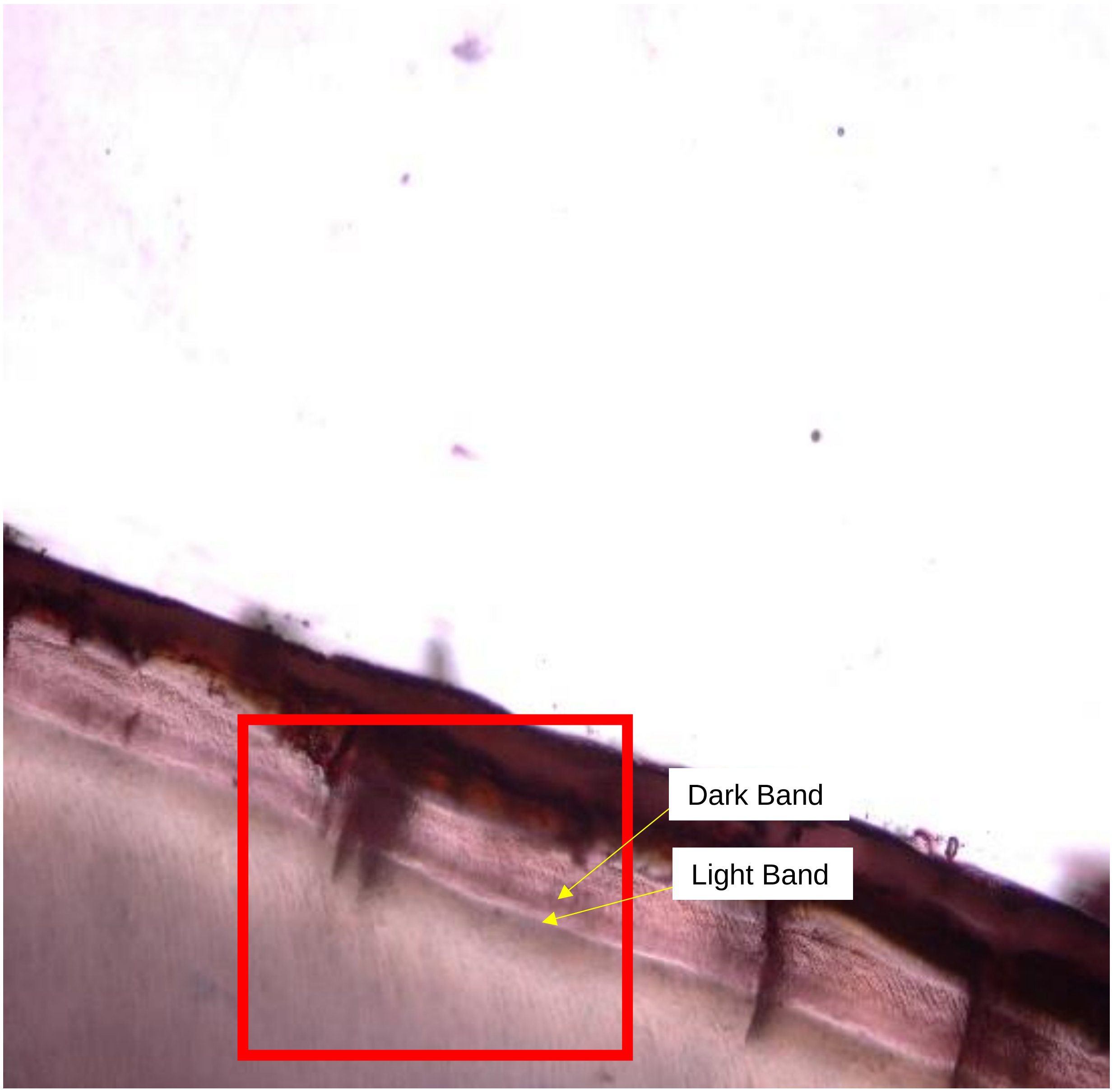

Figure 6.13 Micrograph of Cedar Grove slide #90336B under regular light microscopy at 200x magnification.

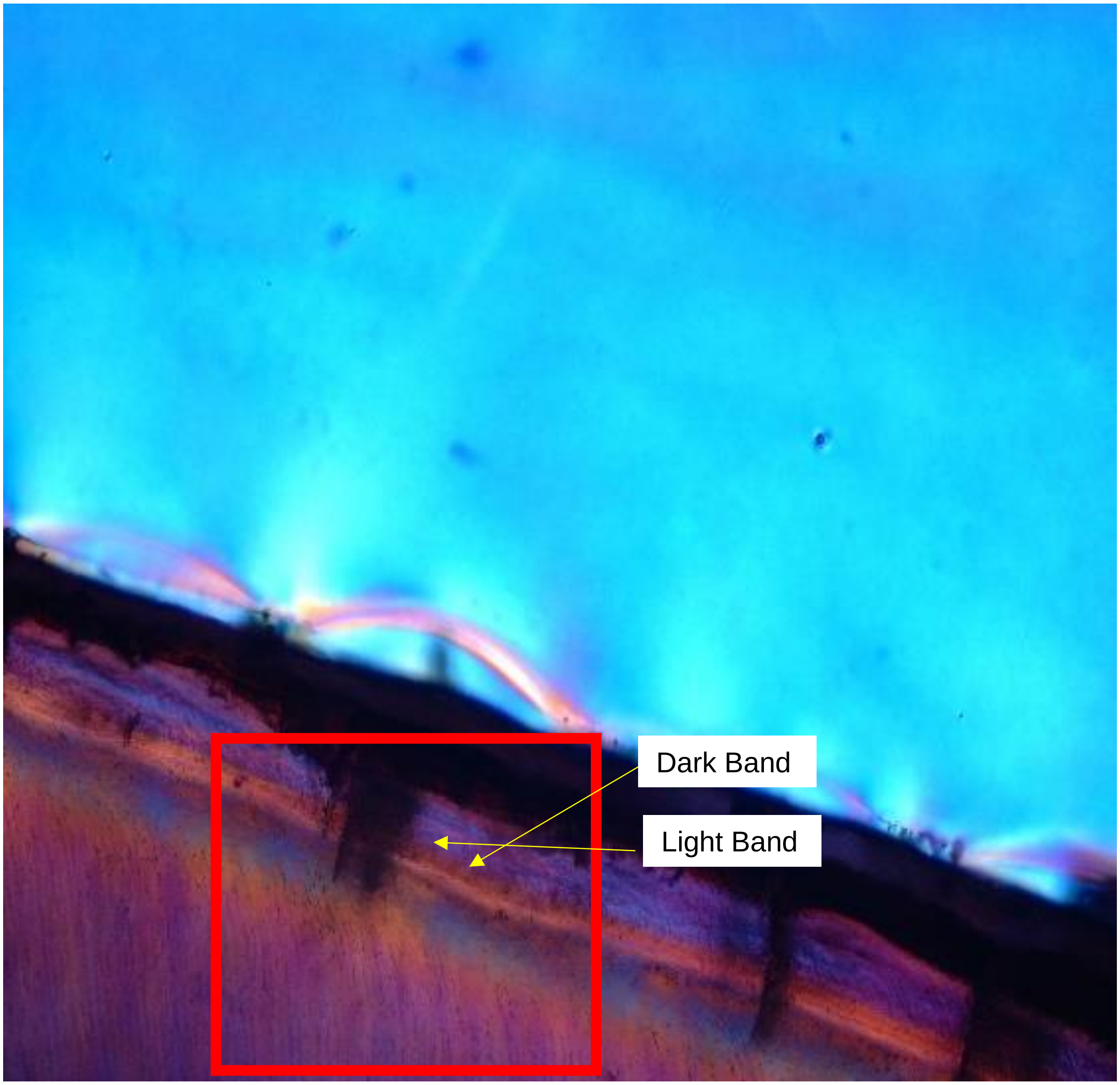

Figure 6.14 Micrograph of Cedar Grove slide #90336B under regular light microscopy and a fluorescent filter, at 200x magnification.

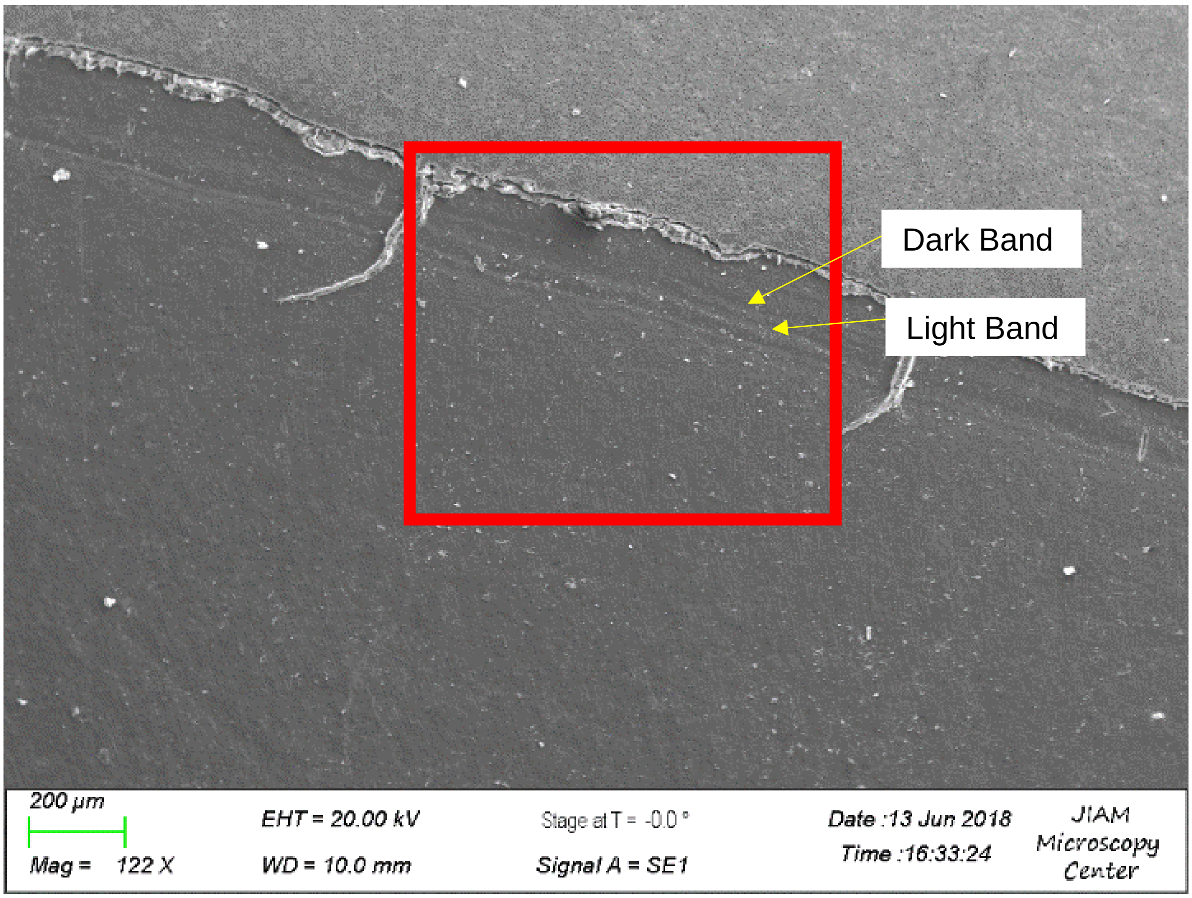

Figure 6.15 Micrograph of Cedar Grove slide #90336B under scanning elcectron microscopy at122x magnification.

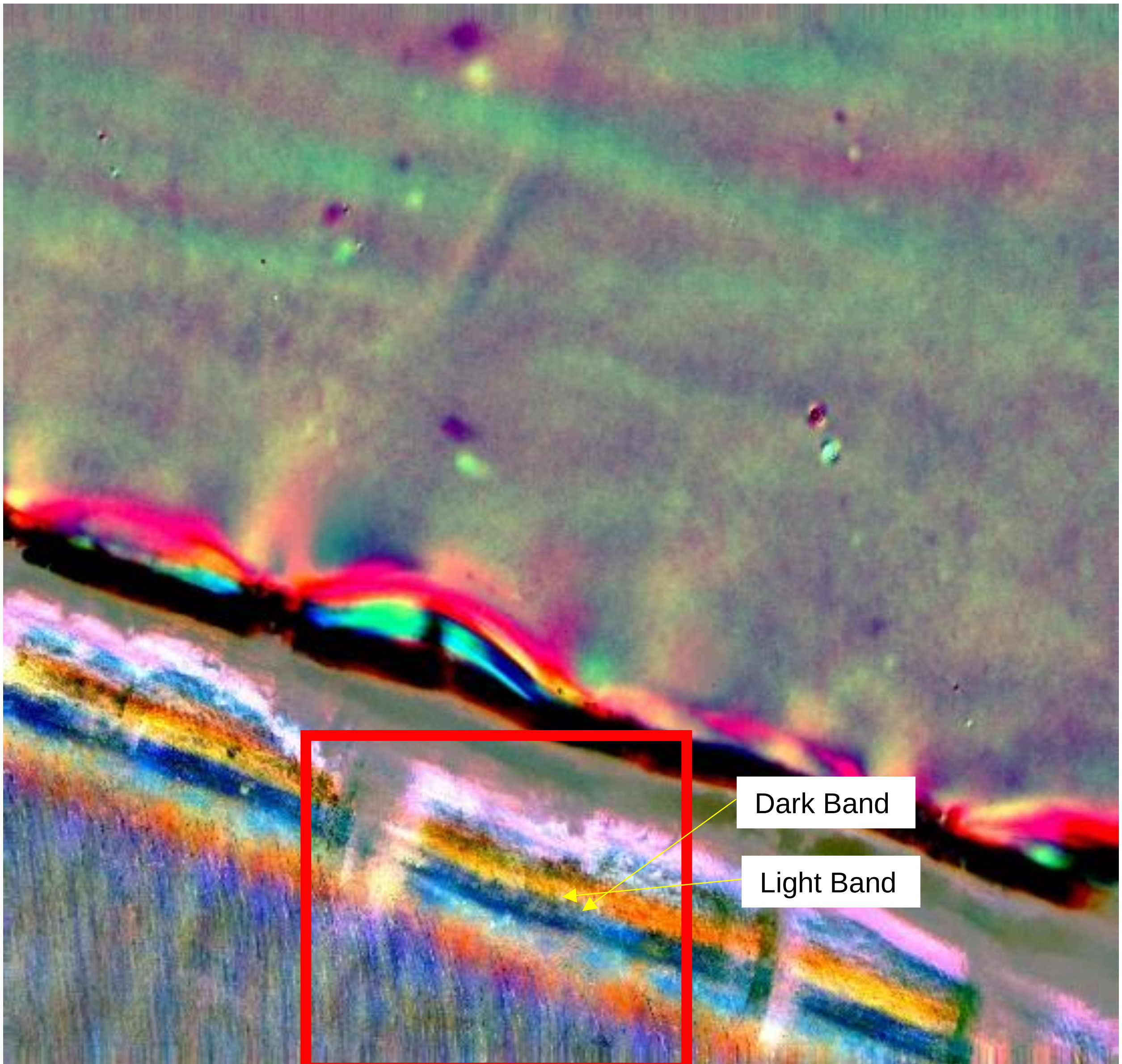

Figure 6.16 Micrograph of Cedar Grove slide #90336B under regular light microscopy at 200x magnification, and digitally enhanced with Adobe Photoshop CC Embossing Tool.

CEDAR GROVE 90336B PART 2

Figure 6.17 Micrograph of Cedar Grove slide #90336B Part 2 under regular light microscopy at 200x magnification.

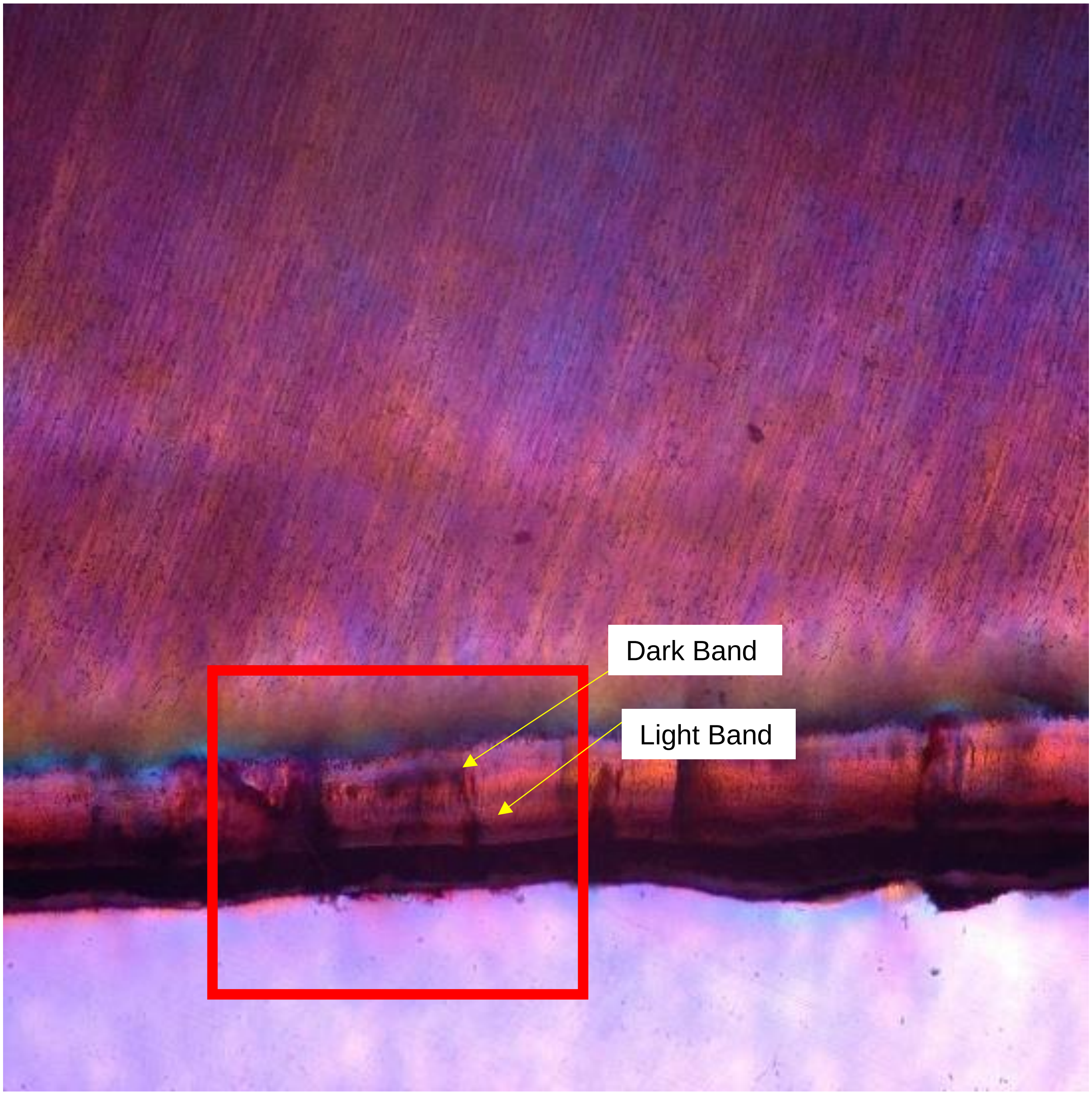

Figure 6.18 Micrograph of Cedar Grove slide #90336B Part 2 under regular light microscopy and a fluorescent filter, at 200x magnification.

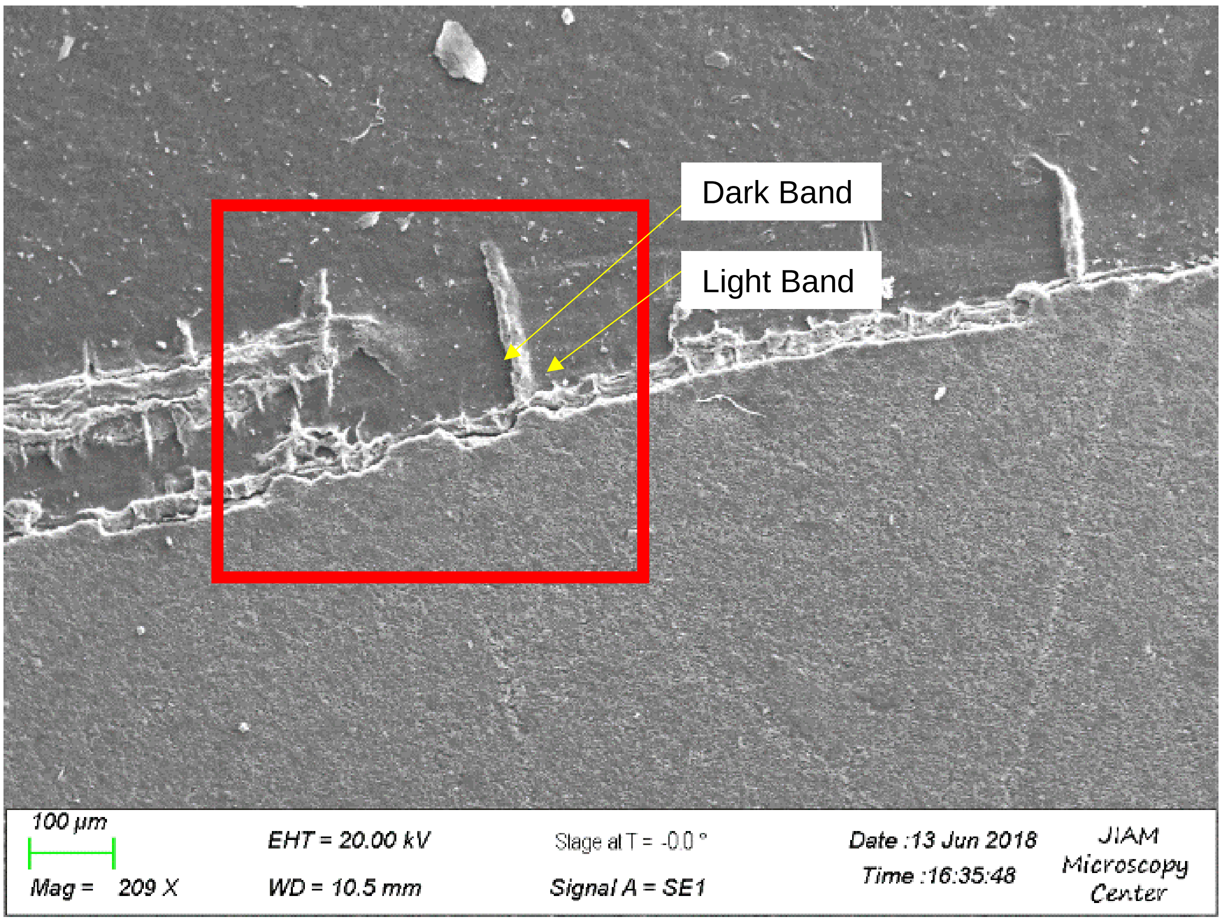

Figure 6.19 Micrograph of Cedar Grove slide #90336B Part 2 under scanning elcectron microscopy at 209x magnification

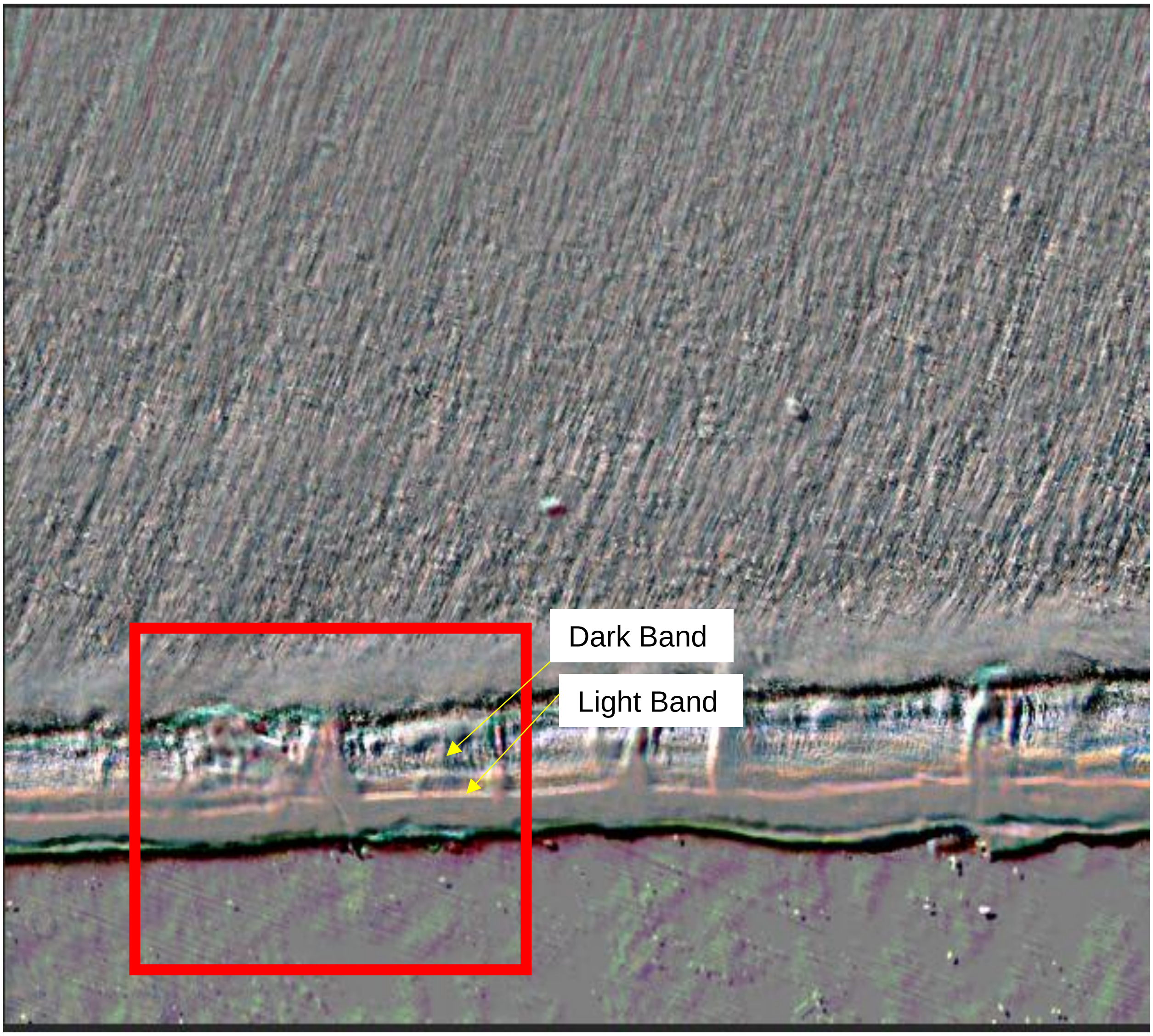

Figure 6.20 Micrograph of Cedar Grove slide #90336B Part 2 under regular light microscopy at 200x magnification, and digitally enhanced with Adobe Photoshop CC Embossing Tool.

CEDAR GROVE 90852

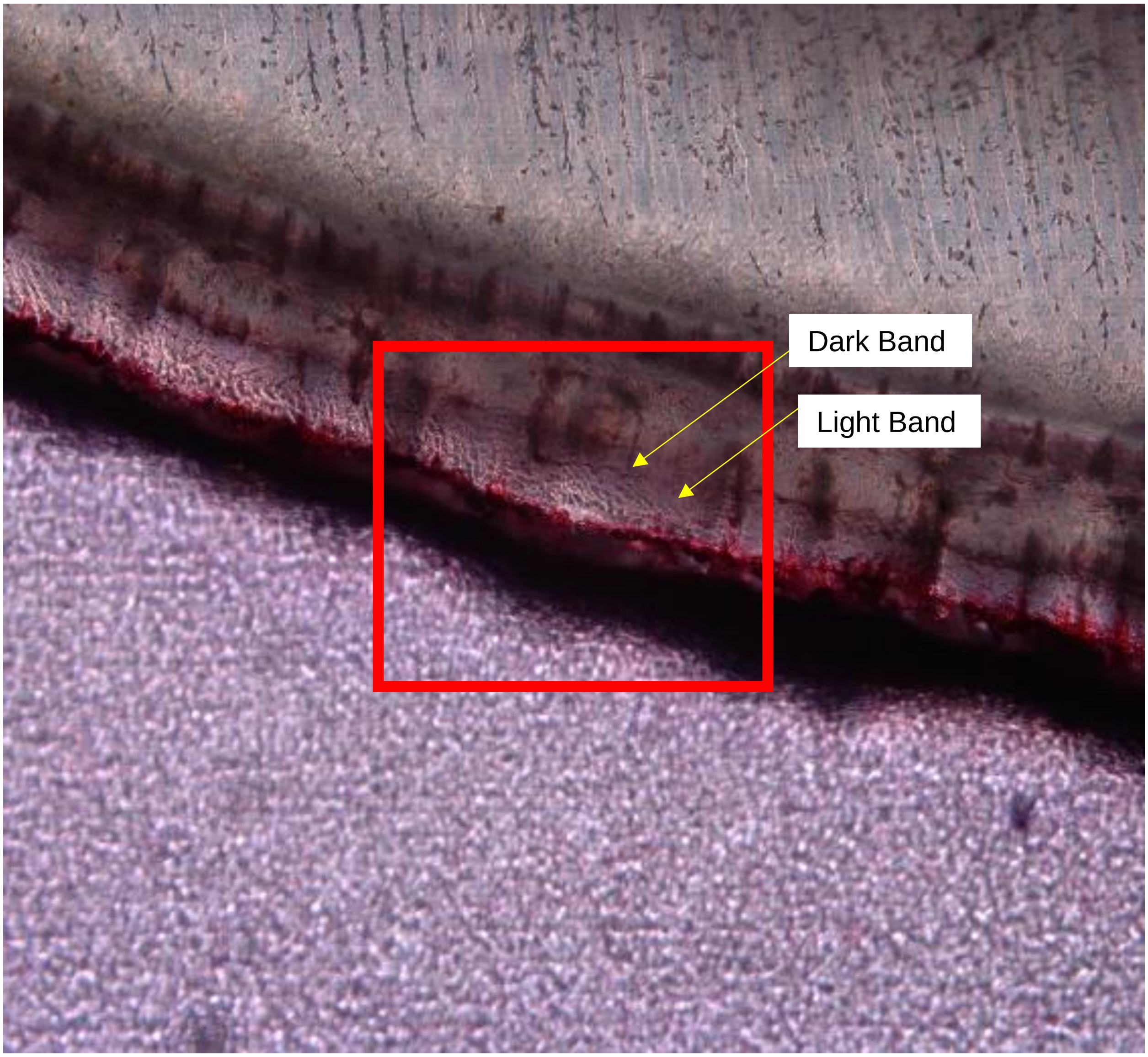

Figure 6.21 Micrograph of Cedar Grove slide #90852 under regular light microscopy at 200x magnification.

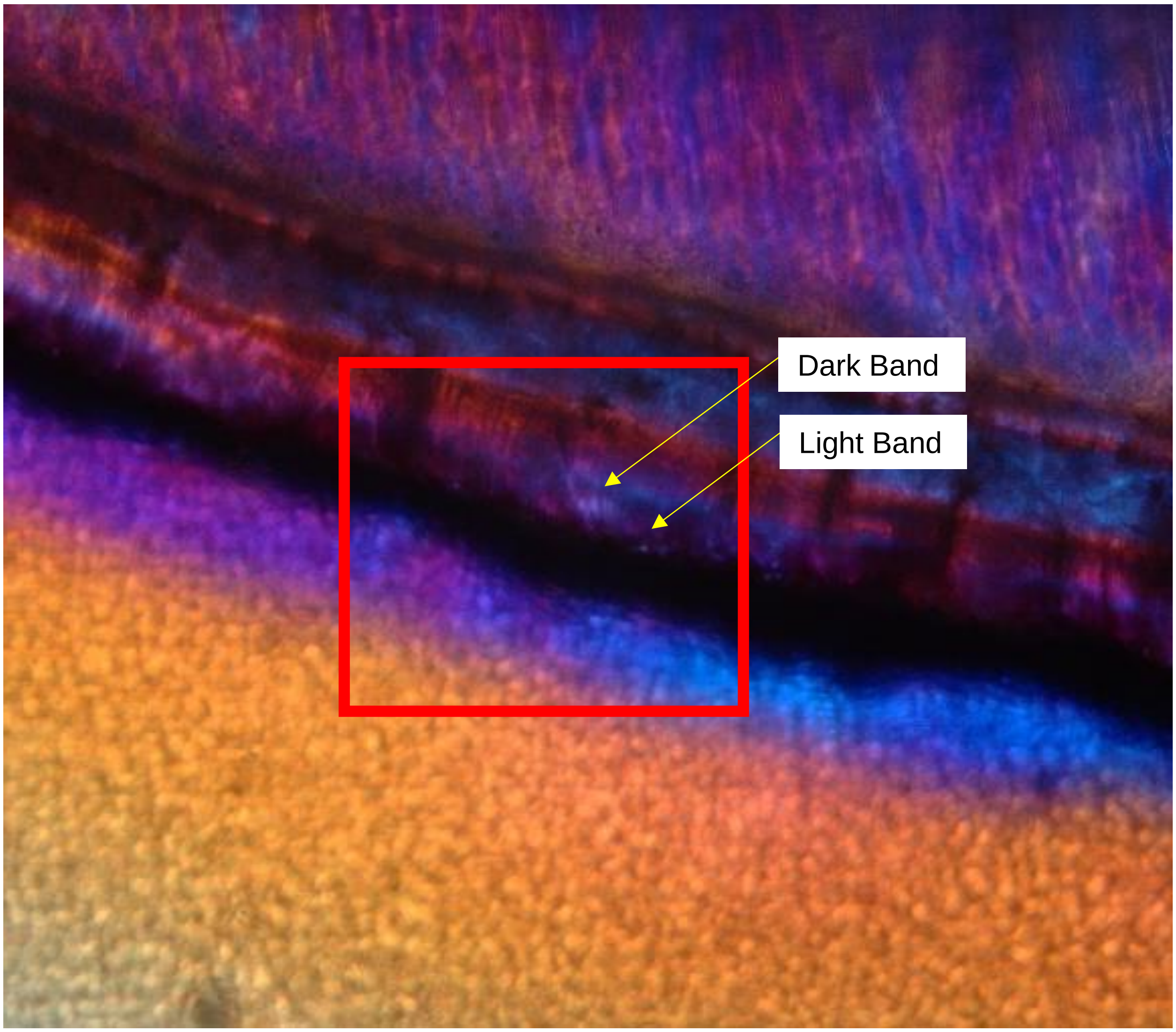

Figure 6.22 Micrograph of Cedar Grove slide #90852 under regular light microscopy and a fluorescent filter, at 200x magnification.

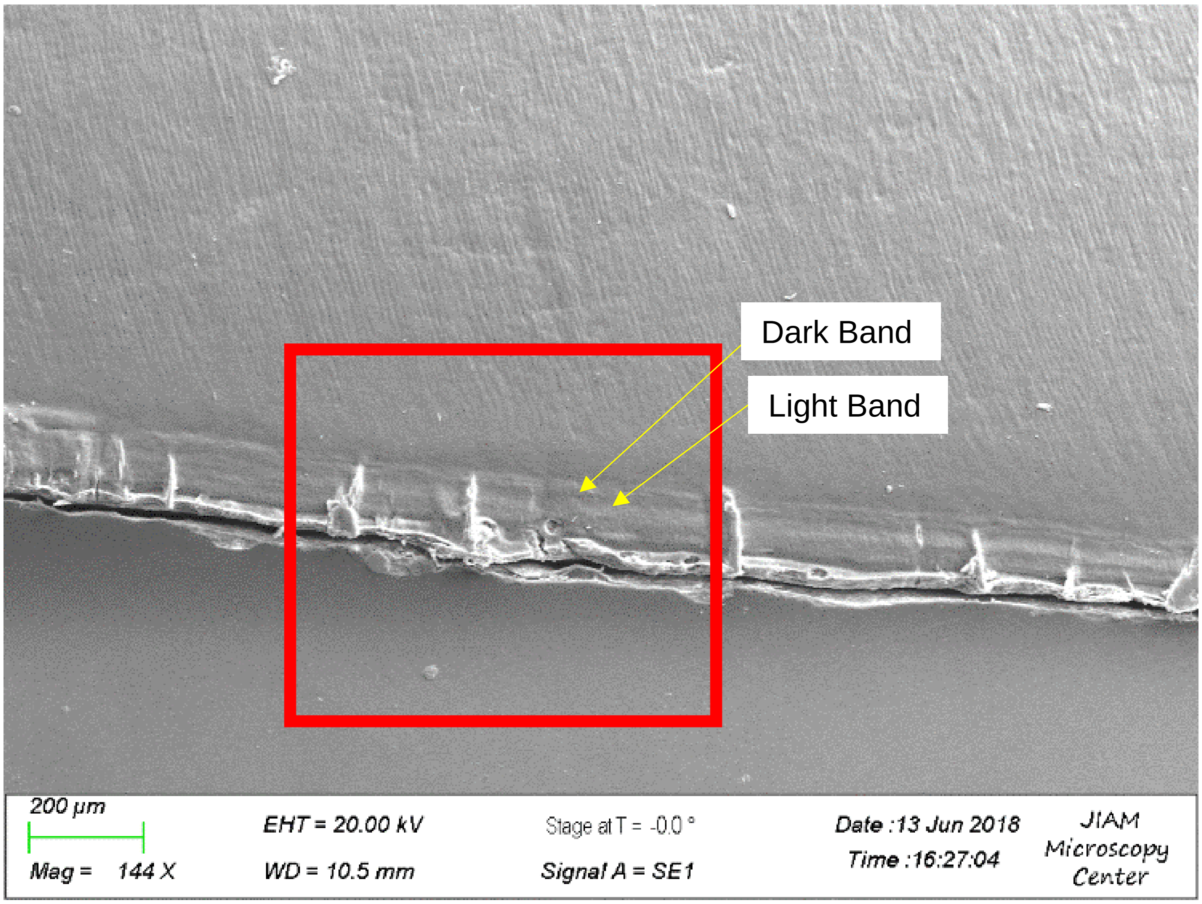

Figure 6.23 Micrograph of Cedar Grove slide #90852 under scanning elcectron microscopy at 144x magnification.

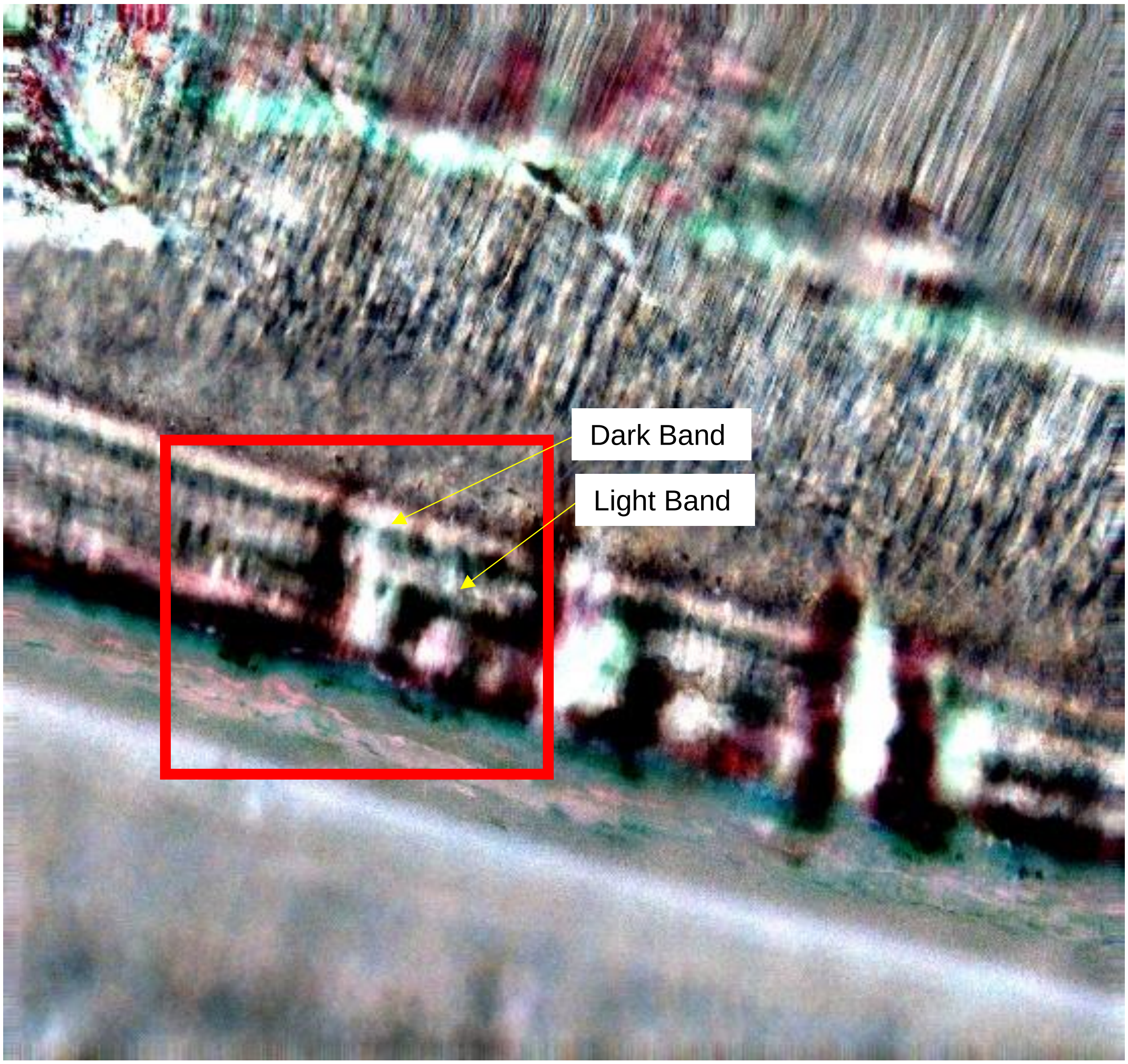

Figure 6.24 Micrograph of Cedar Grove slide #90852 under regular light microscopy at 200x magnification, and digitally enhanced with Adobe Photoshop CC Embossing Tool.

CEDAR GROVE 90852 PART 2

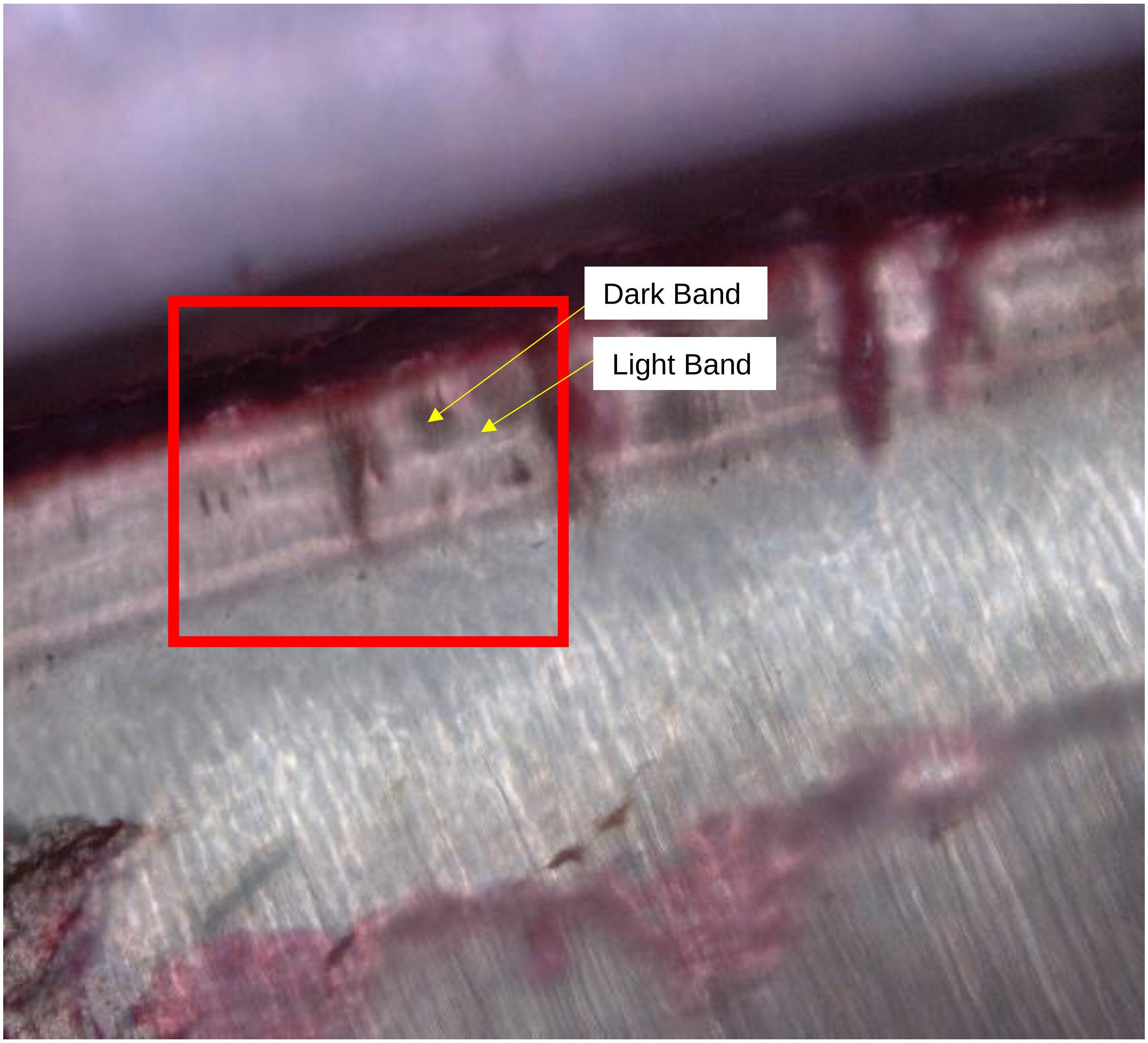

Figure 6.25 Micrograph of Cedar Grove slide #90852 Part 2 under regular light microscopy at 200x magnification.

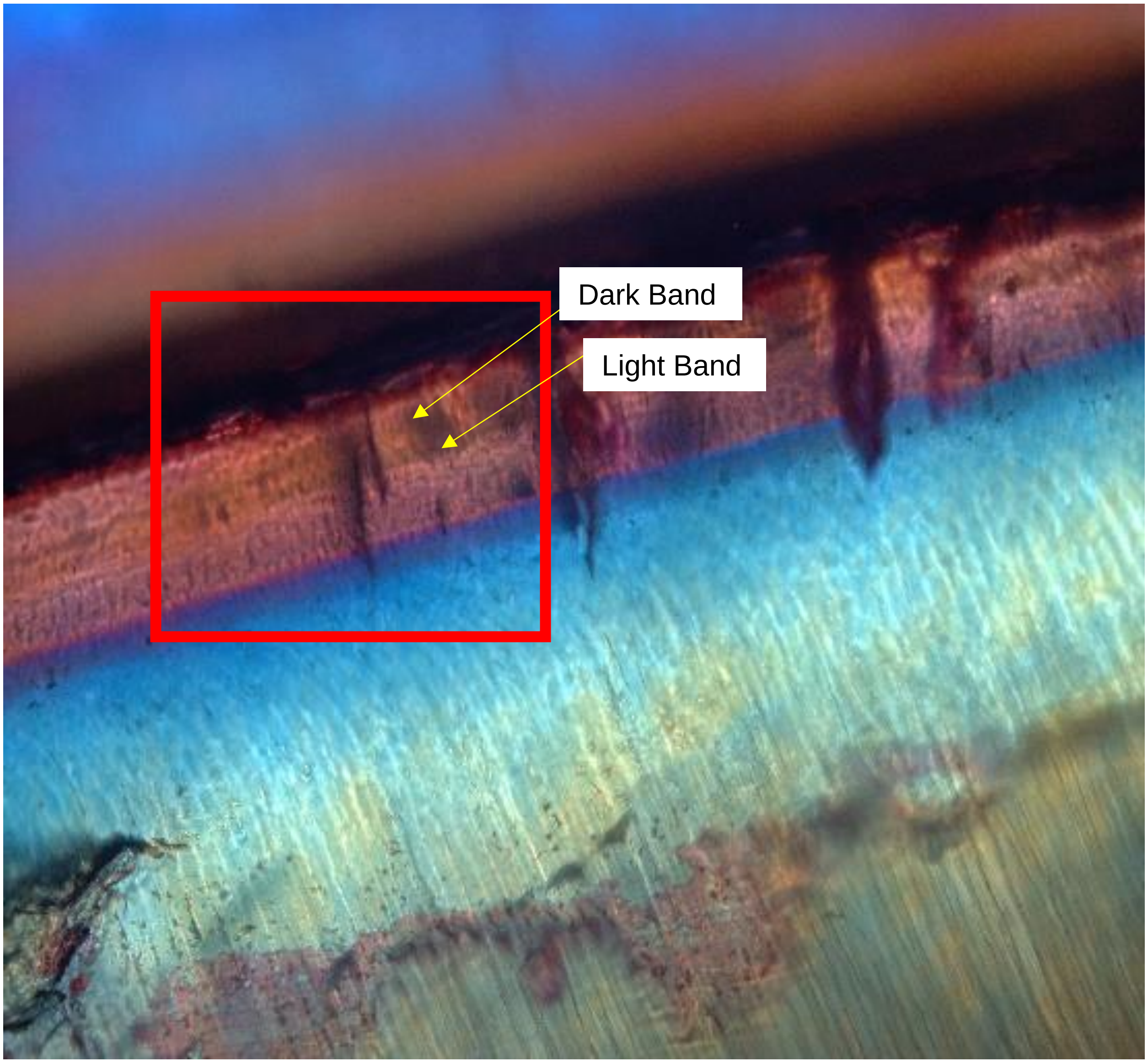

Figure 6.26 Micrograph of Cedar Grove slide #90852 Part 2 under regular light microscopy and a fluorescent filter.

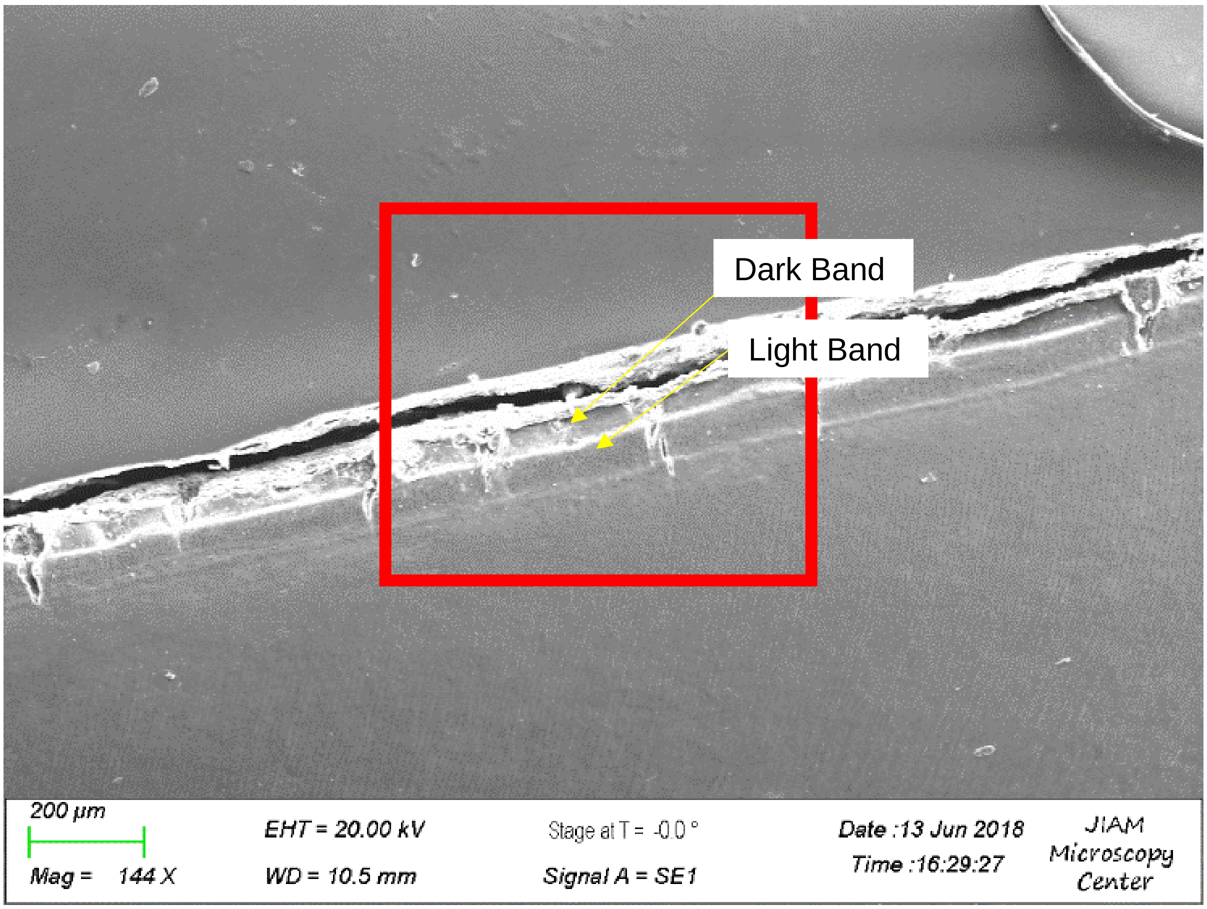

Figure 6.27 Micrograph of Cedar Grove slide #90852 Part 2 under scanning elcectron microscopy at 144x magnification.

Figure 6.28 Micrograph of Cedar Grove slide #90852 Part 2 under regular light microscopy at 200x magnification, and digitally enhanced with Adobe Photoshop CC Embossing Tool.

MB101

Figure 6.29 Micrograph of MB 101 under regular light microscopy at 200x magnification.

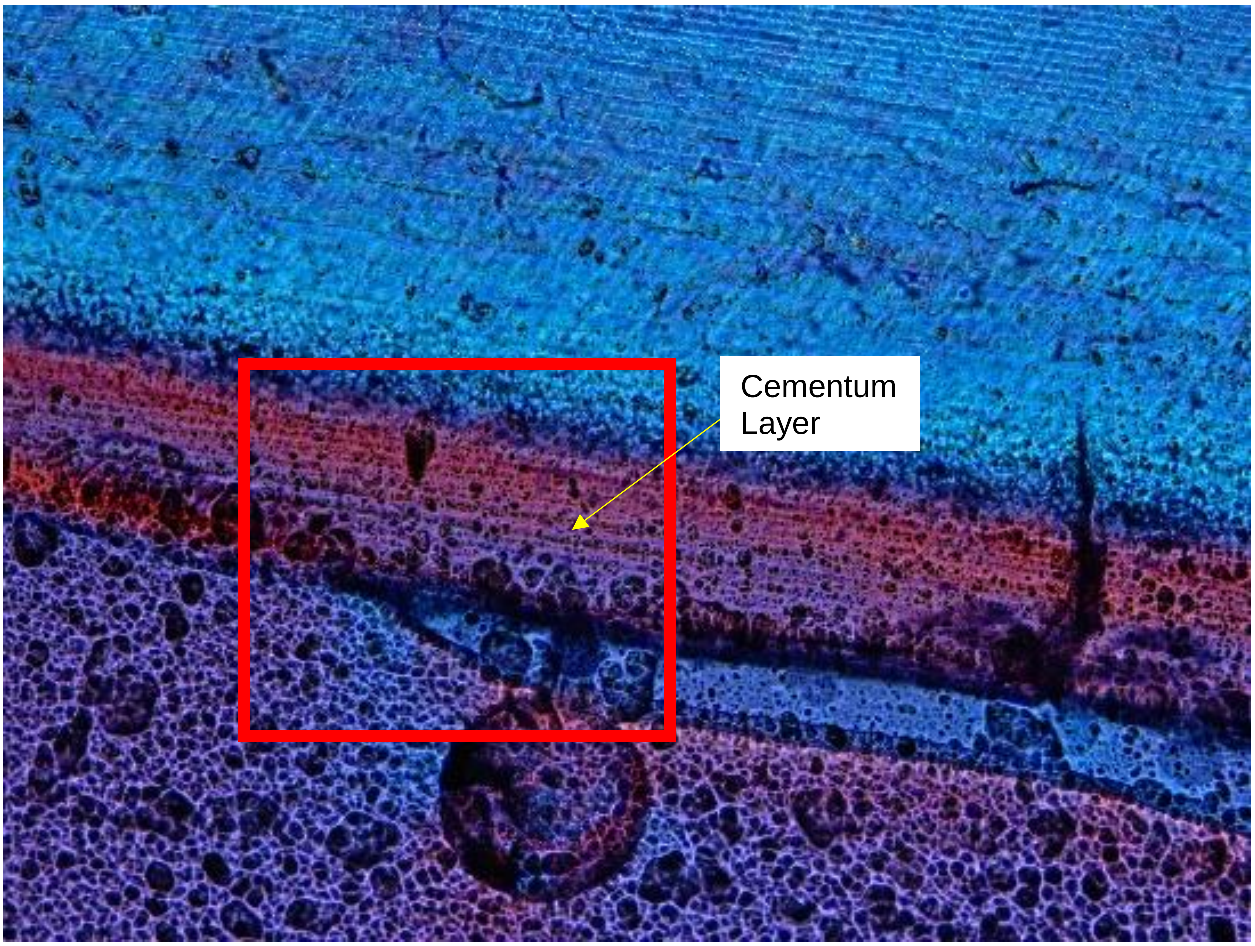

Figure 6.30 Micrograph of MB 101 under regular light microscopy and a fluorescent filter, at 200x magnification.

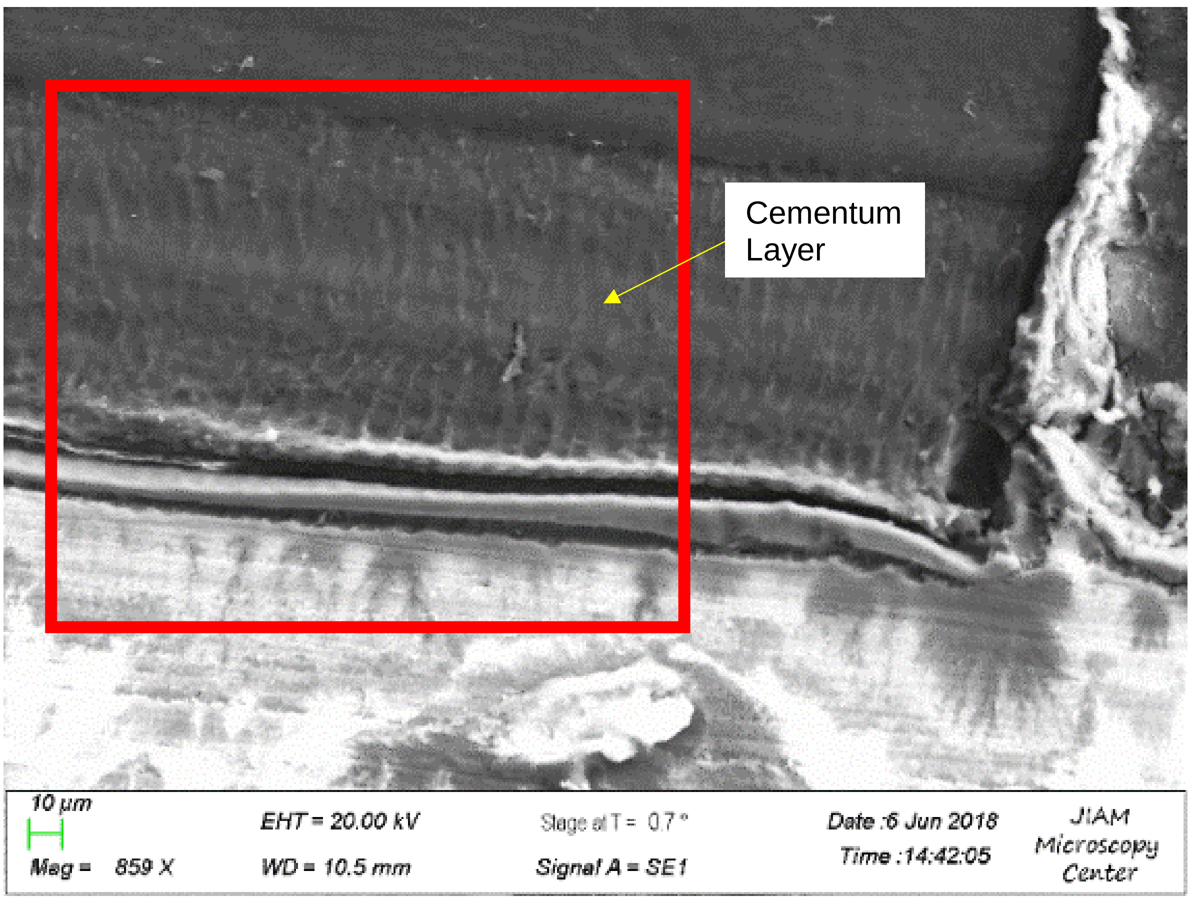

Figure 6.31 Micrograph of MB 101 under scanning elcectron microscopy at 396x magnification.

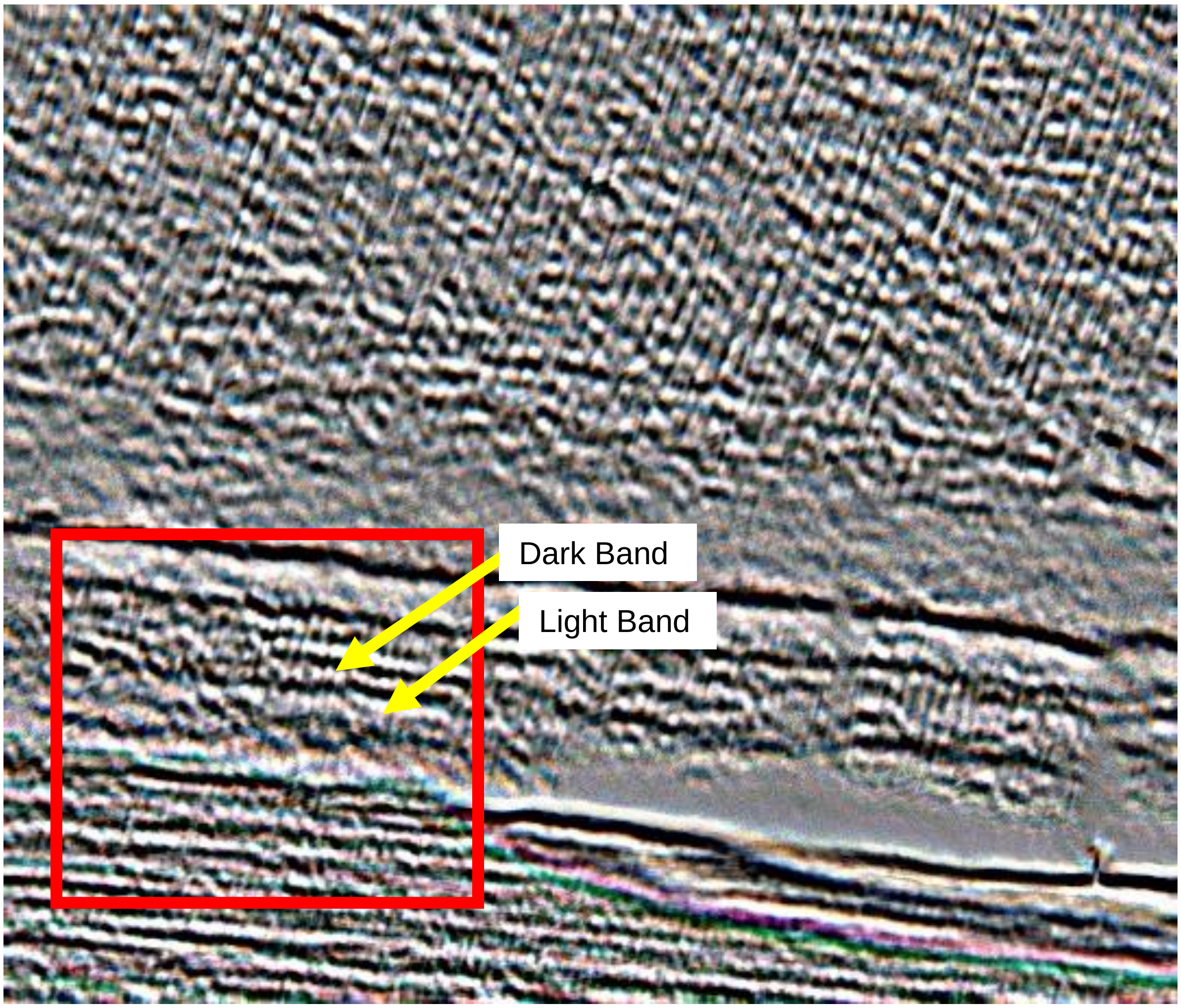

Figure 6.32 Micrograph of MB101 under regular light microscopy at 200x magnification, and digitally enhanced with Adobe Photoshop CC Embossing Tool.

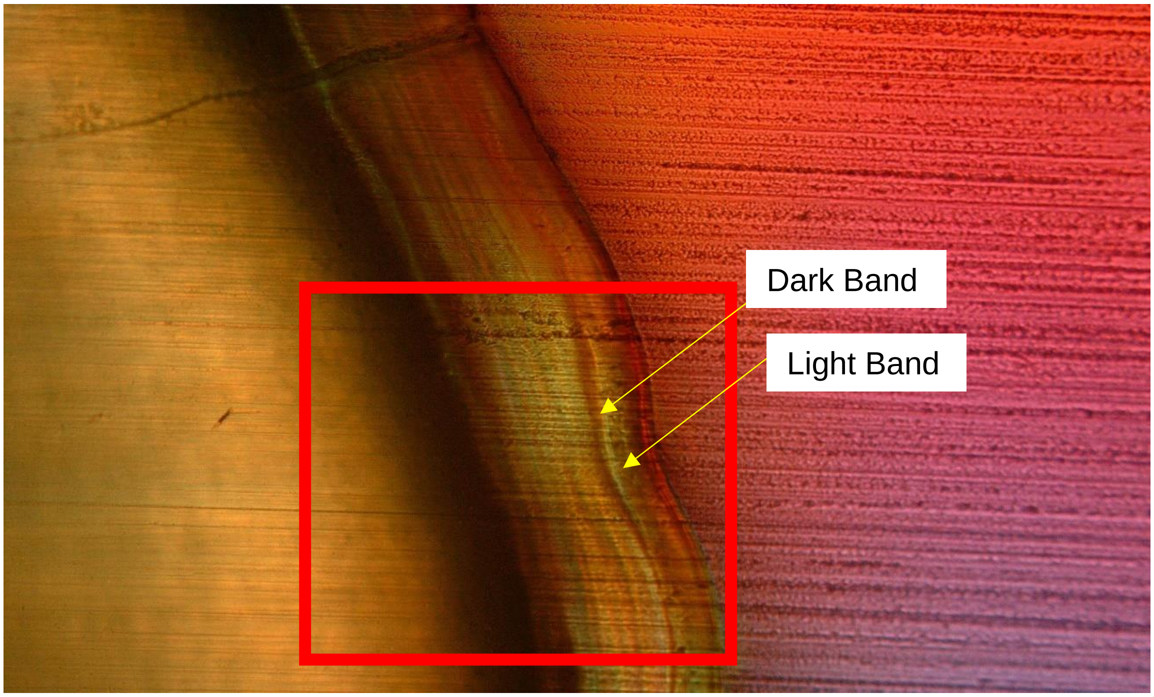

Figure 6.33 Micrograph of the transverse cut thin section under regular light microscopy at 200x magnification.

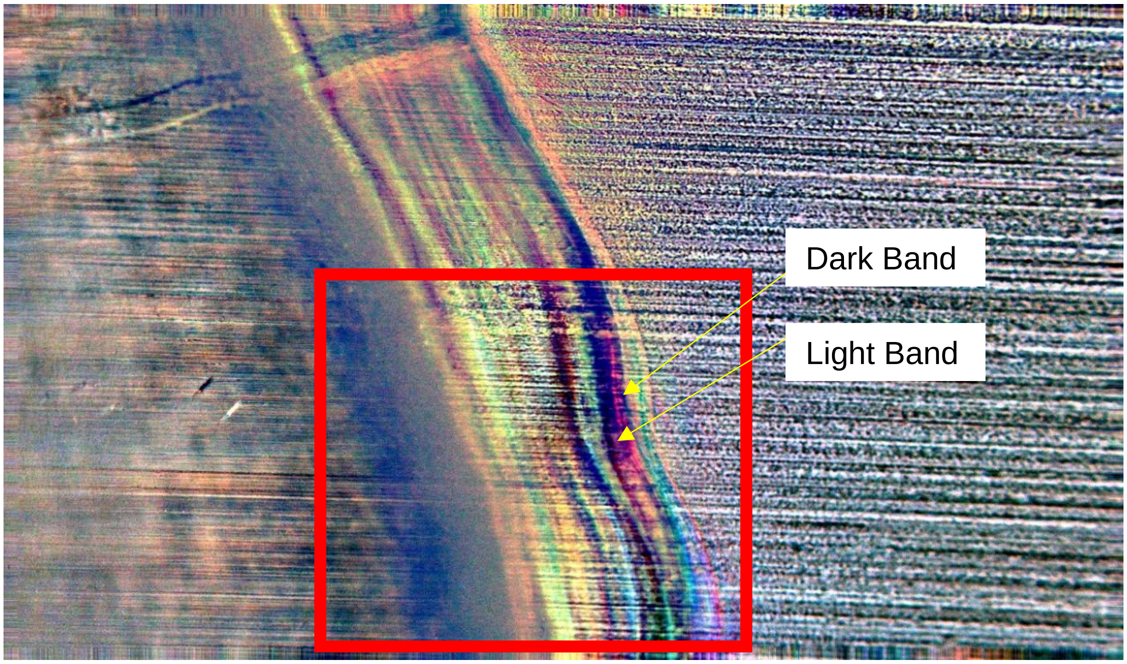

Figure 6.34 Micrograph of the transverse cut thin section under regular light microscopy at 200x magnification and digitally enhanced with Adobe Photoshop CC Embossing Tool.

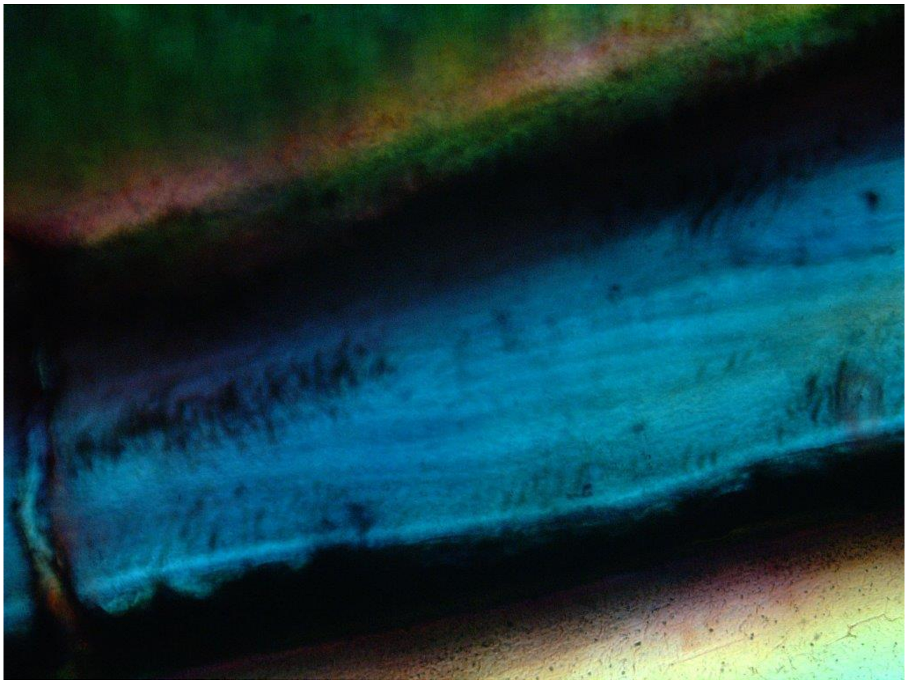

Figure 6.35 Micrograph of thin section using the Von Kossa method under fluorecent light microscopy at 200x magnification.

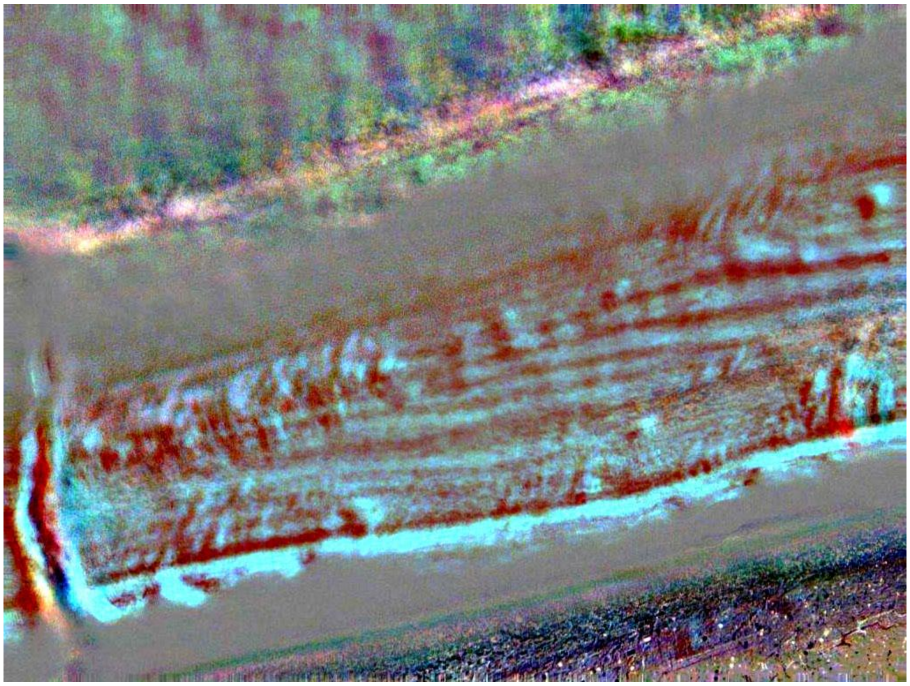

Figure 6.36 Micrograph of thin section using the Von Kossa method under fluorecent light microscopy at 200x magnification and digitally enhanced with Adobe Photoshop CC Embossing Tool.

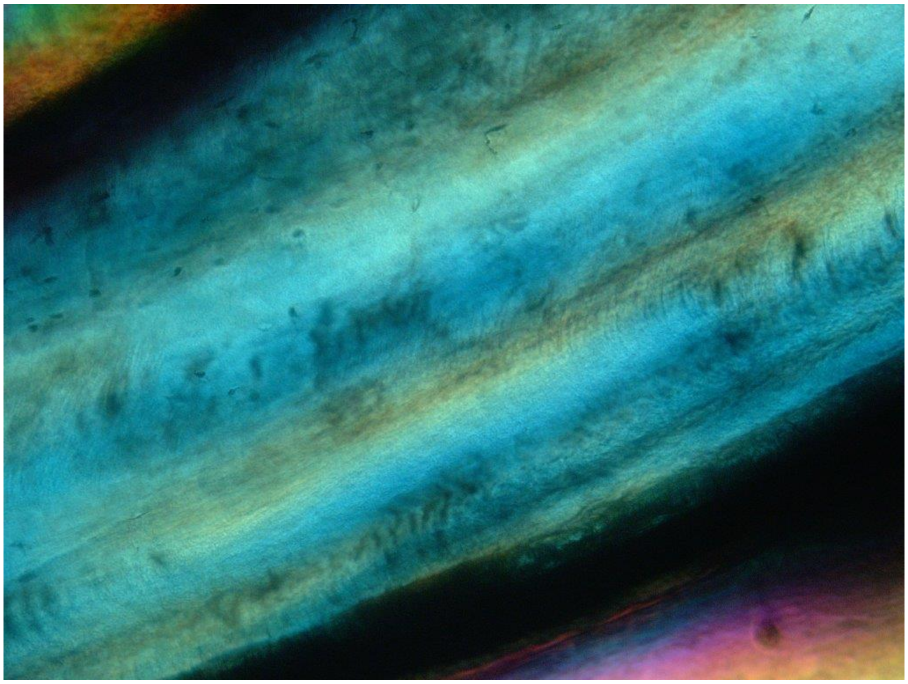

Figure 6.37 Micrograph of thin section using the Von Kossa method under fluorecent light microscopy at 200x magnification.

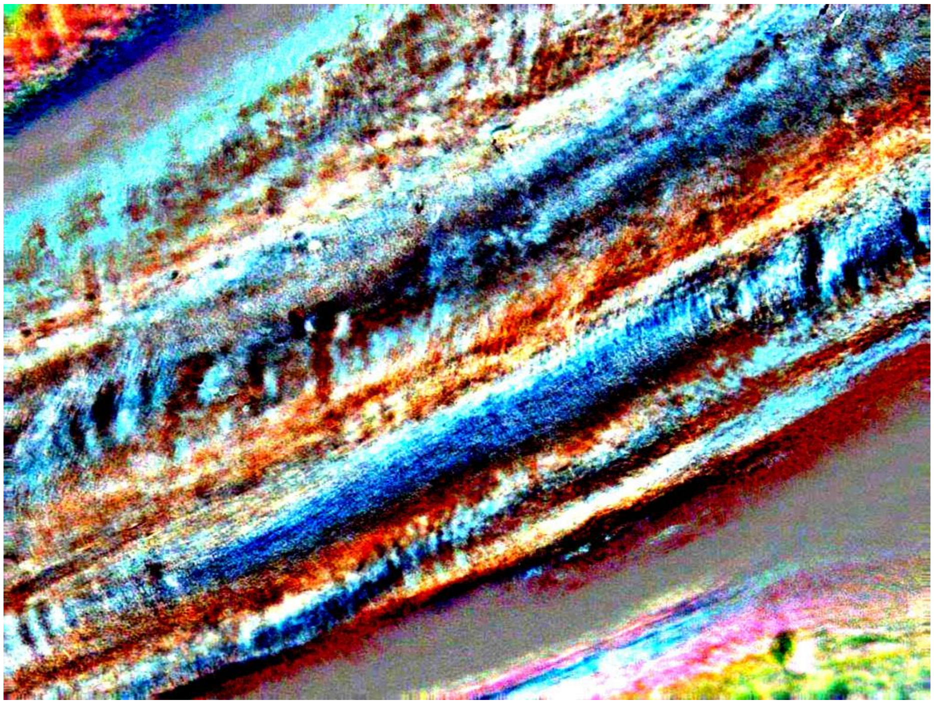

Figure 6.38 Micrograph of thin section using the Von Kossa method under fluorecent light microscopy at 200x magnification and digitally enhanced with Adobe Photoshop CC Embossing Tool.

CHAPTER SEVEN CONCLUSIONS AND RECOMMENDATIONS

This light and scanning electron microscopic research began as a singular effort to document structure and measure changes in cementum of several historic African American burial ground samples dating from approximately 1820-1920. As it progresses it created a twofold question: can cementum be used to analyze the age of these individuals and what is the best methodology in achieving this? Figures 6.1-6.38 shows a progressive timeline to answer these questions.

In observing cementum annuli for the use of age estimation, Charles and coworkers (1986) is a good reference to gain understanding on the topic, and Harris and McKee (1990) is a great resource in understanding the specificity needed for proper analysis. Their research, as a collective, prompted the initial use of hematoxylin and eosin staining as a means to answer this question. Furthermore, it alluded to the use of scanning electron microscopy to enhance results. The results presented in Chapter 6, specifically figures 6.1 through 6.28, triggered the use of the Adobe Photoshop CC Embossing Tool.

The use of the digital imaging enhancement served as a catalyst to modernize, create a methodology in observing cementum. Figures 6.35 through 6.38 demonstrate that the Von Koss method followed by image enhancement is serves as a proper method to display cementum annulations.

Parting thoughts from this research is the notion of applicability of use. As this research sought to document the structure of cementum and standardize a methodology in observing cementum annuli; it achieved that goal. During this process every sample yielded differences that make it difficult to standard a method to yield replicable results on a consistent basis. Cementum holds the capability to be a viable tool for age estimation, but this research suggests it is an undependable method of use.

- Cementum is one of the most accessible biological indicators of the human body with a great amount of potential.
- Though cementum is very accessible and has great potential its findings are not efficiently duplicable to access it.
- While it is possible to obtain higher quality images of cementum annuli its yield of duplicability is not high enough to be an adequate means of age estimation.

LIST OF REFERENCES

Brooks, C. N. B. (2005). Patterns of traumatic injury in historic African and African American populations, Thesis (M.A.) -- University of Tennessee, Knoxville, 2005.

For my master's thesis project titled, ''Patterns of Traumatic Injury in Historic African and African American Populations,'' I examined trauma incidence in American slave and free populations. The objectives of this study were (1) to present frequency and distribution analysis of injuries in each sample, (2) to create cross tabulations to show similarities and differences in each site and compare these results to between, (3) interpret the frequency and distribution of injuries from a cultural aspect, to better understand the violence and physical demands endured by American slaves and freeborn African American. Most of the skeletal samples used in this research have been reinterred. Therefore, this research is based off the observations and interpretations of researchers and data found in published papers. Unfortunately, during the time when most of these remains were examined there existed no universal research method when analyzing skeletal material. Each researcher used his or her own method for analyzing remains; some being more detailed then others. Because of this, this study contains basic information about each site including: site name, total number of individuals examined in each site, total number of individuals observed with fractures, total number of fractures observed in each site, sex of the individuals, which bone(s) were injured, if the injury occurred ante or peri mortem, which are slave communities and which are free populations. Whenever possible a mechanism such as accident, violent encounter or occupational-related injury, was assigned to each injury. For this study trauma was defined as dislocations, fractures, muscle pulls, blunt force trauma and puncture wounds. All bones were examined. There has been a lot of research attempting to reconstruct historic African American lifeways in anthropology. Most of this research consists of analyzing overall health of the populations studied. This study is important because there is not a lot of research specifically on trauma analysis of slave and free populations that discuss the physical demands of slavery as well as slave mistreatment. Due in large part to small sample sizes and fragmentary conditions of slave and African American skeletal series available for study, there is no effective means to measure the biological brutality of slavery. This study is intended to evoke interest in trauma studies in historic African and African American populations. As more studies of trauma in African American populations emerge, more comparisons can be made resulting in important questions being answered about the past. Studies of trauma distribution and frequency patterning in African American populations are essential for addressing questions about human adaptation to physical, environmental, and social constraints.

Cipriano, A. (2002). "Cold stress in captive great apes recorded in incremental lines of dental cementum."

Incremental lines in dental cementum of museum specimens of 11 free-ranging great apes were compared to the respective structures in 5 captive specimens of known age-at-death, and with many known life-history parameters. While the dental cementum of the free-ranging apes was regularly structured into alternating dark and light bands, 4 out of 5 captive animals showed marked irregularities in terms of hypomineralized bands which could all be dated to the year 1963. Cementum preservation was insufficient in the fifth specimen and did not permit such a differentiation. All 4 captive apes had been kept in a zoo located in the northern hemisphere, where 1963 was characterized by an extremely cold winter. Since cold stress is a calcium-consuming process, the lack of available calcium in newly forming cementum could be responsible for the observed hypomineralization. The appositional growth characteristics of dental cementum serve as a record for such life-history events. Copyright (C) 2002 S. Karger AG, Basel.

Dudzik, B. and N. R. Langley (2015). "Estimating age from the pubic symphysis: A new component-based system." Forensic Science International **257**(C): 98-105.

•A component based scoring system for the pubic symphysis is introduced.•Age interval estimates for young adults (≤40 years) are provided.•A flow chart is provided for practitioners to implement.•Method gives accurate age estimates of individuals prior to degenerative changes. The os pubis is one of the most widely used areas of the skeleton for age estimation. Current pubic symphyseal aging methods for adults combine the morphology associated with the developmental changes that occur into the mid-30s with the degenerative changes that span the latter portion of the age spectrum. The most popular methods are phase-based however, the definitions currently used to estimate age intervals may not be adequately defined and/or accurately understood by burgeoning researchers and seasoned practitioners alike. This study identifies patterns of growth and maturation in the pubic symphysis to derive more precise age estimates for individuals under 40 years of age. Emphasis is placed on young adults to provide more informative descriptions of epiphyseal changes associated with the final phases of skeletal maturation before degeneration commences. This study investigated macroscopic changes in forensically relevant modern U.S. samples of known age, sex, and ancestry from the Maricopa County Forensic Science Center in Phoenix, Arizona as well as donated individuals from the William M. Bass Forensic and Donated Collections at the University of Tennessee, Knoxville (n=237). Age-related traits at locations with ontogenetic and biomechanical relevance were broken into components and scored. The components included the pubic tubercle, the superior apex of the face, the ventral and dorsal demifaces, and the ventral and dorsal symphyseal margins. Transition analysis was applied to elucidate the transition ages between the morphological states of each component. The categorical scores and transition analysis ages were

subjected to multinomial logistic regression and decision tree analysis to derive accurate age interval estimates. Results of these analyses were used to construct a decision tree-style flow chart for practitioner use. High inter-rater agreement of the individual component traits (linear weighted kappa values ≥0.665 for all traits in the decision tree) indicates that the method offers unambiguous scoring for age-related changes of the pubic symphysis. Validation of the flow chart on a sample of 47 individuals provided by the Montana State Crime Lab yielded 94% accuracy overall, indicating that the method has the potential to deliver precise and accurate age estimates of individuals prior to the onset of advanced degenerative changes. A pubic symphysis that exhibits epiphyseal changes and/or billowing is suitable for this method
a pubic symphysis that exhibits degenerative changes (i.e. porosity and/or rim erosion) is not suitable.

Guerini, V. (1909). A history of dentistry from the most ancient times until the end of the eighteenth century, Philadelphia and New York: Lea & Febiger.

Hussain, A. and F. Khan (2014). "History of dentistry." Archives of Medicine and Health Sciences **2**(1): 106-110.

Marks, M. K., et al. (1996). "Technical note: Thin section procedure for enamel histology." American Journal of Physical Anthropology **99**(3): 493-498.

Roksandic, M., et al. (2009). "Technical note: Applicability of tooth cementum annulation to an archaeological population." American Journal of Physical Anthropology **140**(3): 583-588.

The use of tooth cementum annulations for age determination has been deemed promising, exhibiting high correlations with chronological age. Despite its apparent potential, to date, the tooth cementum annulations method has been used rarely for estimating ages in archaeological populations. Here we examine the readability of cementum annulations and the consistency of age estimates using a sample of 116 adults from the Iron Gates Gorge Mesolithic/Neolithic series. Our examination of the method pointed to several sources of error that call into question the use of this method for estimating the chronological ages of archaeologically derived dental samples. The poor performance of the method in our analysis might be explained by taphonomic influences, including the effect of chemical and biological agents on dental microstructures. Am J Phys Anthropol 2009. © 2009 Wiley-Liss, Inc.

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In their contribution to the first edition of this Handbook, entitled "The Teeth," LEHNER and PLENK (1936) discussed the tissues constituting the "perio- dontium" rather briefly. In contrast to the detailed paragraphs dealing with, for example, enamel and dentine, the section (about 40 pages and 20 illustra- tions, mostly drawings) devoted to periodontal tissues failed to provide a factual review and summary of the contemporary knowledge and latest developments in research on the various components of the periodontium. Instead, much of the text was an attempt to arrive at conclusions from often purely semantic speculations, playing the various schools of thought against each other, provid- ing arguments in favor of the authors' views and arguments for the feasibility and probability of accepting or rejecting the often diverse opinions, while the reader was referred to the already existing literature for factual details. Since 1936, however, factual details ofthe structural biology of the periodon- tal tissues, i. e. their development, structure, function, and physiology, have been greatly extended and have been internationally accepted. With much less opin- ionated belief to cope with, this knowledge has formed the solid foundation upon which diagnosis, prevention, and treatment in the fields of clinical perio- dontology, modem orthodontics, and re- and transplantation procedures of teeth have been built.

Spinage, C. A. (1973). "A review of the age determination of mammals by means of teeth, with especial reference to Africa." African Journal of Ecology **11**(2): 165-187.

A growing requirement exists to determine the ages of the larger African mammals, concomitant with increasing management. Teeth offer the most practicable means of age determination, but no wholly reliable method, based on teeth, has been demonstrated. Tooth structure, growth and function, are considered, and related to methods of age determination. Methods are divided into those separating groups, and those for determining the chronological ages of groups. The various methods used in these two procedures are evaluated. It is pointed out that studies on the most promising method, cementum line counts, have been neglected in Africa, while methods of determining the ages of large carnivores are virtually uninvestigated, and there is a lack of basic studies describing tooth growth and changes for most large African mammals.

Jane X. Doe was born. She wrote a thesis. She graduated. She followed instructions and wrote her vita in third person and paragraph form (as opposed to a resume or CV), which made her thesis consultant very happy. This page is required.

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Charles, D. K., et al. (1986). "Cementum annulation and age determination in Homo sapiens . I. Tooth variability and observer error." American Journal of Physical Anthropology **71**(3): 311-320.

In order to test the feasibility of cementum annulations to estimate age in humans, observer error and tooth variability in cementum ring counts were evaluated in a sample of 42 mandibular canine and first premolar pairs. Additionally, two sectioning techniques were evaluated. Demineralized thin sections (7 μm) stained with hematoxylin are the preferred technique since their age related variance is greater than 75% for all tooth types examined. In contrast, less than 50% of the total variance was accounted for among individuals when mineralized sections (80 μm) stained with alizarin red were used. Intertooth variability in ring counts of demineralized sections was large

between canines and premolars (43%). Premolars provide counts with lower interobserver error and are the preferred tooth. In an expanded sample (N = 51) of demineralized premolars, intraobserver and interobserver error accounted for 2% and 5% of the total variance, respectively. Evaluation of several experimental designs showed that increasing the number of slides per tooth has the greatest effect on reducing variance followed by increasing the number of observers. Increasing the number of observations has little effect. Cementum ring counts are measurable to a highly repeatable extent and provide a level of repeatability greater than that reported for the pubic symphysis and auricular surface aging techniques.

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A cell that takes part in the formation of *cementum. They are formed from the *dental follicle

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When an individual reaches the age of legal majority, their treatment within the criminal and civil legal systems is changed dramatically in the United States. Forensic odontologists are often asked to assist government agencies in estimating the ages of persons who may or may not have reached that legally important age. The third molars are the only teeth useful as forensic estimators of chronological age in the target age group. This study reviews the principles, methodology, and population data of the most commonly used technique in the United States, the analysis of the third molar development based on modified Demirjian staging. The method analyzes the developing third molar to estimate mean age, age intervals and the empirical probability that an individual has reached the anniversary of her or his eighteenth birthday.

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Senn, D. R. and R. A. Weems (2013). Manual of forensic odontology. Boca Raton, FL, Boca Raton, FL : Taylor & Francis.

Spinage, C. A. (1973). "A review of the age determination of mammals by means of teeth, with especial reference to Africa." African Journal of Ecology **11**(2): 165-187.

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Weinand, D. C. (1997). Increment Studies of White-Tailed Deer (Odocoileus Virginanus) From Coastal Georgia. Graduate School, University of Georgia. **Master of Science:** 112.

Wilson, R. J. (2005). The health status of early 20th century Blacks from Providence Baptist Church Cemetery (40SY619) in Shelby County, Tennessee, Thesis (M.A.) -- University of Tennessee, Knoxville, 2005.

Paleopathological investigations of health are an important component in the construction of a population's history. Such studies make possible analyses regarding Black health in the late 19th and early 20th centuries, a time period where the availability of relevant and objective literature is limited. Also, these investigations permit a comparison between similar populations to determine the extent to which the demographic, social, economic, and political conditions of this time period affect a specific population. This study compares the Providence Baptist Church cemetery in Shelby County, Tennessee to two contemporary historic Black cemeteries in order to address an urban versus rural dichotomy suggested by Davidson et al. (2002). The Cedar Grove cemetery, located in rural Arkansas, and the late-period Freedman's cemetery, located in Dallas, Texas, were used for the comparison. Comparisons of the skeletal and dental indicators of stress across these samples, using data from the
Western Hemisphere Database (Steckel et al. 2002), help place the Providence Baptist Church skeletal series in relation to the other sites. A series of pair-wise chi-tests was employed to determine significant differences at the 95 percent confidence level, between the populations for the frequency and severity of each skeletal indicator of stress. The Providence Baptist Church cemetery demonstrates a high incidence of degenerative joint disease, moderate infectious lesions, few dietary or metabolic disorders, and little trauma. When compared to the other populations, the pathology frequencies indicate a population that is not clearly associated with either the rural or urban condition as defined by Davidson et al. (2002). Significant variation among the three sites was observed with each stress indicator examined. The Providence population demonstrated a relationship with the Cedar Grove Cemetery for osteoarthritis, and with Freedman's Cemetery for indicators of metabolic stress. The
results for trauma and infection were inconclusive, but a possible relationship between Cedar Grove and Providence for trauma and between Freedman's and Providence for infection was noted. These pathological conditions indicate a rural community that is augmenting its health status by taking advantage of the resources at its disposal. This suggests that other factors, such as a direct church affiliation, an association with Masonic organizations, or the proximity to the Memphis metropolitan area affected the population's health.

Wittwer-Backofen, U., et al. (2004). "Tooth cementum annulation for age estimation: Results from a large known-age validation study." American Journal of Physical Anthropology **123**(2): 119-129.

Recent research indicates that tooth-cementum annulations (TCA) may be used more reliably than other morphological or histological traits of the adult skeleton to estimate age. Until now, however, confidence intervals for age estimated by this method have not been available for paleodemographic and forensic applications. The present study addresses this problem. Based on a large known-age sample, age estimates by TCA were conducted in a blind study involving 363 teeth. Tooth-root cross sections were made using a refined preparation technique. Improved digital graphic procedures and enhancement strategies were used to produce digital images with a specially adapted software package. This resulted in high concordance between the TCA age estimates and chronological age. Assessment of the method's accuracy, as expressed by 95% confidence intervals, showed that error bounds for age estimates do not exceed 2.5 years. Sex differences, intraindividual correlations, and the effects of periodontal disease were studied. None of these indicators had a quantitative effect on the number of TCA bands when the proposed methodological standard was followed. We conclude that the TCA technique is a reliable method for estimating a subject's age from cementum annulations. Am J Phys Anthropol 2003. © 2003 Wiley-Liss, Inc.

Womack, R. (2003). MSCAA v. Federal Express Corporation and All Interested Parties, Chancery Court of Shelby County, Tennessee No. CH-03-0454-1. C. C. o. S. C. T. f. t. T. J. D. a. Memphis.

VITA

Kortney DeWayne Powell was born in Memphis, TN, to Carol Pollard Powell. He is the younger brother to Kenneth Powell Junior. He attended Alton Elementary, Downtown Elementary, Bellevue Middle, and continued to Central High School in Memphis, Tennessee. After graduation, he relocated to Knoxville, TN to attend the University of Tennessee. During his time at the university he blossomed in leadership working in the division of Enrollment Management, Academic Affairs - ultimately serving as the Senior Student Adviser to the Provost and Senior Vice Chancellor. Outside of his academic and professional career, Kortney served as the Executive Director of Catering and Auction Coordinator for VolThon - the UT extension of the Children's Miracle Network Dance Marathon program. He obtained a Bachelor of Science degree from the University of Tennessee, Knoxville in August 2017 in Food Science and Technology, and subsequently began his graduate studies in Comparative and Experimental Medicine, concentrating in Forensic Odontology. During this time, he was able to work with notable members in the forensic community such as: Bill Bass, Murray Marks, Jim Lewis and Thomas David. While pursuing this degree Kortney worked as a Graduate Student Assistant in the Office of Research and Engagement, Office of Community Engagement and Outreach. In this role, Kortney was able to help reinvigorate the university engagement portfolio, a critical part in the university's classification as a highly engaged public land-grant institution by the Carnegie Foundation.