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Cluster Bands, Wilson Bands and Pit Patches: Histological and Enamel Surface Indicators of Stress in the Black Mesa Anasazi Population

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Abstract.

There is little concensus on methods for classification of enamel surface and histological defects, reflecting an under lying lack of understanding of the variability in expression of enamel to physiological disruption. In order to further explore the range of variation in the response of enamel to disruption, and the relationship between surface and histological features, we studied forty-six permanent canines from the Black Mesa Anasazi (A.D. 800-1150). Archaeological and paleopathological studies of the Black Mesa population suggest that it was a politically and ecologically marginal group that experienced a considerable degree of chronic malnutrition and morbidity.

Detailed macroscopic and microscopic observations were made of variations in enamel surface contour and histological features. Eighteen teeth (39.1%) exhibited a linear enamel hypoplasia. More common were areas of depressed enamel, called pit patches (41.3%). Nearly two thirds of teeth (62.5% had a pit patch or a clear linear enamel) defect. Histological sections exhibited relatively few unambiguous Wilson bands (including prism bending; 17.4%). However, a great many «cluster bands» were found (37.0% of teeth; Goodman & Rose, 1990), often associated with pit patches, linear enamel hypoplasia, and a scalloped dentin-enamel border. Based on correlates of pit patches and cluster bands, and the archaeological and paleoepidemiological reconstruction of life on Black Mesa, we propose that both pit patches and cluster bands may be manifestations of chronic physiological disruptions.

Introduction.

Research into the etiology and adaptive significance of enamel developmental defects may be characterized by a series of phases during which scientists increasingly recognize the complexity of their subject. During the 1930's and 1940's, the first «golden age» of study of enamel defects (Goodman & Rose, 1990; Suckling, 1989), it seemed to have been unambiguously assumed that linear enamel hypoplasias (LEH) were a clear, indelible, and chronological recorder of past stresses (Sarnat & Schour, 1941).

Some of these tennants remain relatively unaltered (enamel defects are largely indelible once formed and most can be traced with some confidence to a development of time). However, with increased concern for practical implications and better experimental designs, the initial naivete has given way to deeper understanding. Whereas much remains secure in theory, application lagged. How, for example, in the face of poor standards for enamel development, and individual and population level variation, can one best estimate the age of an individual at the time of development of a defect (Swardstedt, 1966; see Berti & Mehaney, this volume)? What degree of severity and duration of malnutrition, or other developmental insult, is required to precipitate an enamel defect (Kreshover, 1960; Sweeney & al., 1971)?

In the 1980's, an even wider variety of problems began to receive consideration. Among these were concerns for the significance of both theoretical and practical issues such as, variation in susceptibility of ameloblasts to developmental disruption across taxa and individuals, and within and among teeth. How is this variation explained, and what is its evolutionary significance (Condon, 1981; Goodman & Armelagos, 1985; also see Condon & Rose, this volume)? A second key problem area focuses on the relationship between enamel surface defects and histological structures. If there is a close and consistent relationship, as is theoretically predicted, then is it possible to devise a system by which one can accurately predict histological structure from surface observations (Goodman & Rose, 1990)? Finally, the fundamental problem of how one can distinguish normal stria of Retzius from pathological accentuations has emerged. What is the variation in pathological responses, and is there more than one «type» of response (Rose, 1979)?

The purpose of this study is to describe the enamel surface defects and histological structures of a series of teeth from the Black Mesa Anasazi. Few studies have thus far compared enamel surface and histological defects (Karhu, 1991 is a noteworthy exception). In the following paper we present the frequency and chronological pattern of enamel surface and histological defects. Particular attention is paid to pit patches, an area of depressed enamel on enamel surface involving multiple hypoplastic pits, and cluster bands, histological defects characterized by a sudden series of accentuated stria of Retzius that offer a variable expression of Wilson band characteristics. We propose that both pit patches and cluster bands, two infrequently considered enamel features, may be indicators of chronic malnutrition and disease stress.

Methods and Populations.

Black Mesa Anasazi: Culture, Health and Nutrition.

Black Mesa is located within the desert plateau region of the American Southwest in the northeastern corner of Arizona. The mesa, which is approximately 250 square kilometers in area, contains a complex system of temporay washes. Utah juniper and pinyon are predominant tree species. It is considered by archaeologists to have been marginal and generally unfavorable for large-scale intensive crop production, but there is clear evidence for maize agriculture since at least A.D. 100 (Dean, 1988).

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Black Mesa was populated largely by farmers living in small dispersed groups. Corn agriculture augmented foraging of wild plants and hunting (primarily deer and rabbits). Resources for gathering and hunting were widely dispersed and of generally low yield with the potential to support only a very small number of people (Ford, 1984). Although the advent of agriculture allowed for larger populations to exist throughout the entire occupation of Black Mesa, food resources were never abundant or predictable. The most salient feature of the Black Mesa midden and site remains of plants and animals is its diversity and variability. Storage and redistribution of foodstuff may have added an additional buffer against nutritional stress (Powell, 1983).

The burials from Black Mesa (n = 172) were excavated between 1967 and 1983 by the Black Mesa Archaeological Project of Prescott College and Southern Illinois University. Although there was sporadic habitation and use of Black Mesa as early as 6000 B.C., excavated habitation sites with associated skeletal remains are primarily from the period between A.D. 800 to 1150. Distribution of individuals by age and sex support that the skeletal population is fairly representative of precapitalist agrarian populations (Weiss, 1973). Burials were divided into an early Pueblo (A.D. 800-1050) and late Pueblo (1050-1150) phase. This division corresponds to the growth in population in the early phase, and the decline in population after A.D. 1050 that occurred along with a cessation of building activity. Extended habitation, which ceases on Black Mesa sometime after A.D. 1150, correlates with a decrease in water tables and precipitation, and an increase in soil erosion.

The Black Mesa skeletal population is unique and important because it documents biological and cultural adaptation to a highly marginal environment. The Black Mesa environment is highly risky, with few good locations for agriculture, and wide fluctuations in climatic and hydrologic variables essential for successful harvests (Dean, 1988). However, archaeological evidence suggests that because the Black Mesa Anasazi were behaviorally and culturally innovative and versatile, they persevered and survived for many generations (Gumerman, 1988). Archaeological interpretations suggest that the Black Mesa Anasazi had to be extremely innovative to remain in an area as harsh and ecologically unstable as Black Mesa. Powell and colleagues (1983:233) comment that «the Anasazi occupation of Black Mesa is a story of continual adaptive change in systems that probably never experienced periods of stasis».

Additionally, the Black Mesa Anasazi represent a politically and economically autonomous group. This is significant because at the same time, large and politically centralized populations, such as at Chaco Canyon and Mesa Verde, existed in other areas of the Southwest. These large sites have been used to characterize the prehistoric American Southwest when in fact the vast majority of the Anasazi did not live in great cultural centers but rather in thousands of small rural farming settlements outside the boundaries of the larger sites (Gumerman, 1984).

A detailed analysis of skeletal pathologies demonstrates that the Black Mesa Anasazi were to some degree physiologically compromised and that health was generally poor, but the data do not support a population in demise (Martin & al., 1991). There were no statistically significant differences between the early and late Pueblo phases in terms of skeletal pathologies.

Of the 172 individuals, most showed some signs of iron deficiency anemia (87%). However, there is an indication that iron deficiency did not contribute significantly to mortality because the majority of the lesions show signs of healing and were slight in involvement (64%). The lesions which were active and severe were primarily confined to the youngest individuals. For Black Mesa infants and children who died young, there is indisputable evidence for the presence of iron deficiency anemia. The group most at risk are infants between birth and two years, where the most severe cases of anemia occur.

Nutritional anemia co-occurred with infection in 62% of the cases. In general, almost half of the children show some infectious disease involvement. The Black Mesa children aged 6-10 years also show signs of infectious disease. This is unusual because other reports commonly site the age group of 1-4 years as being the most afflicted with infections (Mensforth & al., 1978). One interpretation of this finding is that there were repeated but non-lethal bouts of infection affecting the children. Chronic, but relatively mild, transmissible diseases may have been endemic on Black Mesa. The infections may have been persistent enough to re-infect older children, but mild enough for them to show recovery.

Based on long bone lengths, most individuals, both adults and subadults, might be considered to have suffered from mild-to-moderate malnutrition. Interestingly, adults show more severe growth stunting than children, suggesting that malnutrition was chronic and catch-up was not dominant. A prior study of linear enamel hypoplasia showed that 85% of the individuals from Black Mesa had one or more defects, with a peak occurrence at ages 2-4 years (Martin & al., 1991).

A summary of the paleopathological data suggest that nutritional stress was ubiquitous on Black Mesa throughout the occupation. A picture emerges of endemic, mild-to-moderate nutritional stress that had an impact on almost all age and sex groups. The generally mild nature of the iron deficiency, the pervasiveness of childhood growth disruption, and the clustering of pathologies around infancy and weaning, all point to a difficult existence, but also to an ability to respond and recover from bouts of poor health (Martin & al., 1991).

Enamel Surface Defects.

For this study, one permanent canine was chosen for analysis from all individuals with one or more of these teeth. Canines missing more than half of their crowns due mainly to occlusal attrition were excluded from the sample. A total of forty six teeth are included.

All teeth were removed from their sockets and cleaned. Tooth crown heights, as well as labial-lingual and mesial-distal maximum breadths were measured. In addition, attrition was estimated in order to assess the proportion of the crown lost to analysis. With the aid of a binocular microscope, both lingual and labial enamel surfaces defects were examined for the presence and location of developmental defects. Defect type was recorded based on a modification of the Federation Dentaire International (FDI, 1982; Clarkson, 1989) classification. Because a great many defects involved areas of depressed enamel,

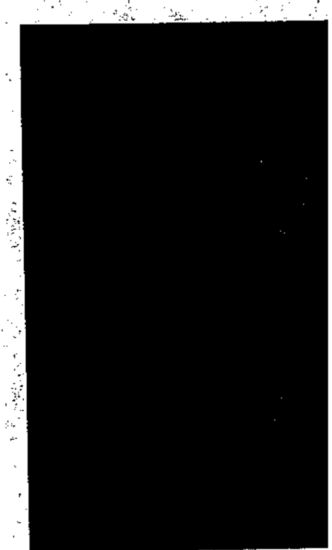

Figure 1. Example of a «pit
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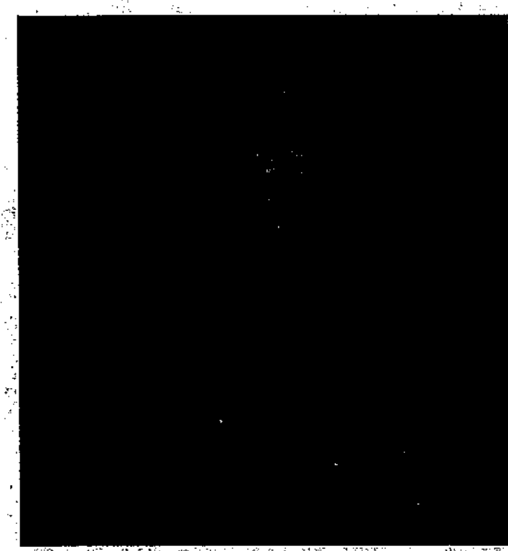

Figure 1. Example of a «pit patch» type surface defect.

often centered on the mid-labial surface, these defects were further described. Most were eventually classified as «pit patches», an area of depressed enamel that involves a series of pits arranged in a non-linear fashion (Figure 1). Finally, the location of all defects was recorded as a distance from the cemento-enamel junction (CEJ). In the case of thin linear defects, the distance from the center of the defect to the CEJ was recorded. In the case of wide defects, the upper and lower borders of the defect were measured from the CEJ. These distance measures were then used to estimate the age at formation of hypoplastic defects following methods outlined in Goodman & Rose (1990).

Histological Defects.

After observation and recording of enamel surface defect types and locations, teeth were embedded in Buehler epoxide resin and placed in a vacuum for approximately five minutes in order to remove air bubbles. After drying overnight, molds were pealed away and labial-lingual sections, approximately 100 microns thick, were cut with a Buehler Isomet low-speed, diamond saw. Sections were cleaned with ethanol, mounted on slides, and etched with 1N HCl for fifteen seconds.

Following Condon (1981; Condon and Rose, this volume) three criteria were used for classification of a Wilson band: (1) stria of Retzius that extends from surface to DEJ, (2) presence of an accentuated stria on both labial and lingual sides, and (3) prism bending (Figure 2). Because lingual enamel was frequently destroyed, we consider a true Wilson band to be one that meets the first and third criteria. In addition, stria that meet only the first criteria are noted and referred to as accentuated stria of Retzius.

Histological observations were made with an Olympus BH-2 microscope. All enamel sections were first observed at 40x for degree of extension of the stria of Retzius and presence of an accentuated stria of Retzius on both labial and lingual surfaces. Prism bending was observed at higher magnification: 100, 200 and 400x.

Rose & Goodman (1990) have recently discussed the presence of a phenomena termed «cluster banding». A cluster band is defined as a series of clearly visible stria of Retzius that extend through most of the enamel thickness. These stria tend to bend and converge near the enamel surface (Figure 3; also see Goodman and Rose, 1990:70). Cluster bands sometime incorporate Wilson bands.

Figure 2. Prism bending in interior enamel. Photograph was taken at 400 magnification with a polarizing microscope.

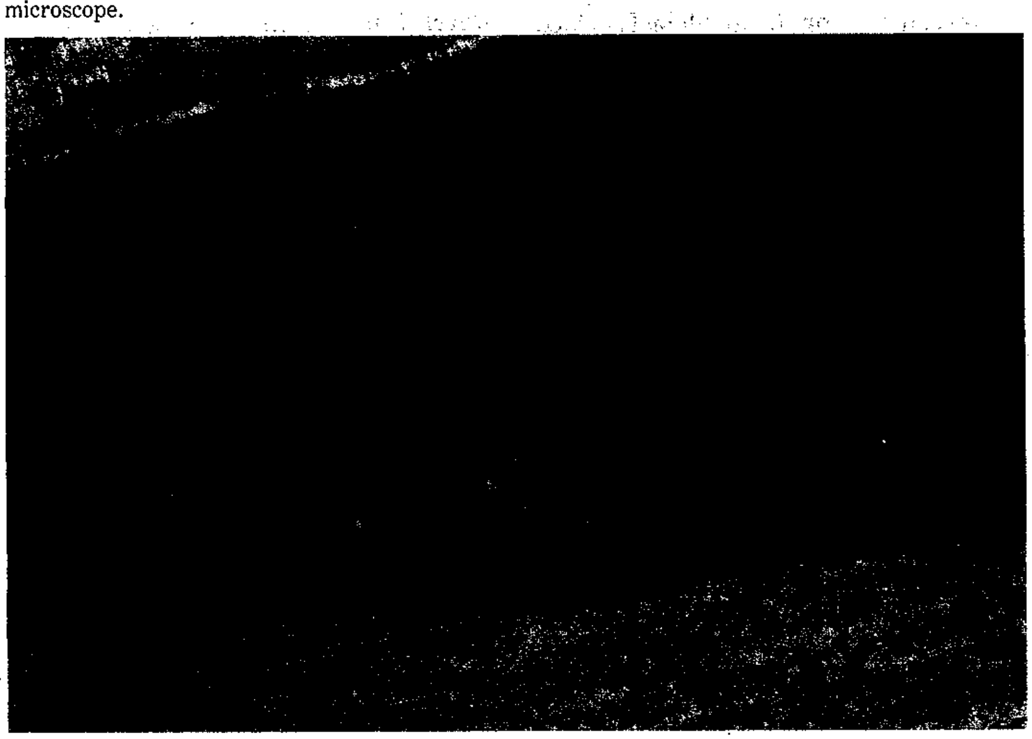

Figure 3. Cluster Banding. Note the bending and convergence of stria of Retzius and the scalloped bordered DEJ.

Results.

Enamel Surface Defects.

Five different type defects were observed and gle pits, pit patches, opac 1 or 2), moderately sever hypoplasia (FDI type 4), enamel hypoplasia. A tot distinct enamel surface recorded on forty-six t tooth). Thirty-seven (80. one or more defects. Fiv had an enamel opacit yellow-brown discolora most of the cervical ha crown (Table 1). Eightee exhibited a clear LEH (19.6%) displayed one hypoplasias. In total, (47.8%) had a mild or mo (Table 1). Although less teeth displayed a LEH, si ed five or six hypoplasi repeat stress episodes.

Four teeth (8.7%) dis labial surface pit (Table expectedly, nineteen teet classified as involving o patches. These frequentl tively spherical shape. slightly linear pattern v LEH was seen to coe patch.

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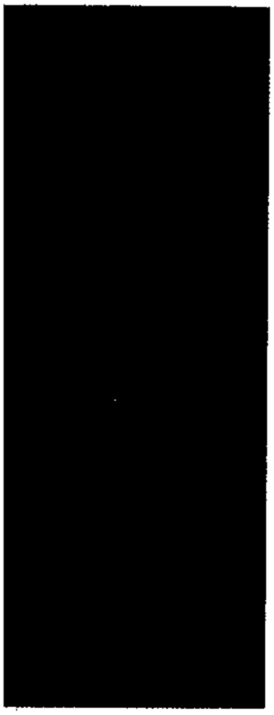

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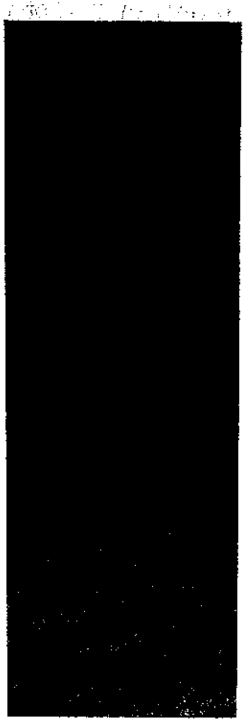

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Results.

Enamel Surface Defects.

Five different types of enamel defects were observed and recorded: single pits, pit patches, opacities (FDI type 1 or 2), moderately severe linear enamel hypoplasia (FDI type 4), and mild linear enamel hypoplasia. A total of eighty-six distinct enamel surface defects were recorded on forty-six teeth (1.87 per tooth). Thirty-seven (80.4%) teeth had one or more defects. Five teeth (10.9%) had an enamel opacity, typically a yellow-brown discoloration, covering most of the cervical half of the tooth crown (Table 1). Eighteen teeth (39.1%) exhibited a clear LEH and nine teeth (19.6%) displayed one or more mild hypoplasias. In total, 22 individuals (47.8%) had a mild or more severe LEH (Table 1). Although less than half these teeth displayed a LEH, six teeth exhibited five or six hypoplasias, suggesting repeat stress episodes.

Four teeth (8.7%) displayed a single labial surface pit (Table 1). Rather unexpectedly, nineteen teeth (41.3%) were classified as involving one or more pit patches. These frequently formed a relatively spherical shape. Sometimes a slightly linear pattern was found, or a LEH was seen to coexist with a pit patch.

The individuals' ages at development of hypoplastic defects (LEHs and pits) were estimated based on the Massler & al. (1941) chronology (Table 2). No enamel defects were found to have developed before 18 months of age. Conversely, the majority of defects developed between four and five years of age. Light lines, however, seem to occur somewhat earlier than clear LEHs and pits.

Accentuated Stria of Retzius, Wilson Bands, and Cluster Bands.

A total of fifty-two (1.13 per tooth) stria of Retzius met one or more of Condon and Rose's criteria for Wilson bands (this volume). Of these, thirty-four (65.4% of defects) met only the single criteria of transversing the labial enamel from surface to DEJ (Table 1). An additional four defects met some combination of criteria but could not be considered true Wilson bands because they did not involve prism bending. The remaining fourteen defects, found on eight teeth (17.4%), are considered to be true Wilson Bands as they transversed the section and involved prism bending.

A total of twenty cluster bands were found on seventeen (37.0%) teeth. Thirteen teeth (28.2%) have a cluster band and *not* an associated (embedded) Wilson band, and four teeth (8.7%) have a Wilson band within a cluster band.

Wilson bands and accentuated stria of Retzius that extend from the surface to the DEJ most often occur within the middle portion of tooth crowns. Both types of defects occur somewhat radomly throughout the crown, thus estimated ages at formation do not yield a clear single peak (Table 3).

Whereas the Wilson band chronology might be characterized as irregular, the cluster bands display a highly constant level of involvement. Starting at one year of age, over twenty percent of all half year developmental periods have a cluster band (Table 3, Figure 4).

Finally, we have observed in our histological sections that the DEJ is frequently scalloped (Figure 3). While the scalloped borders frequently co-occur with cluster banding, the relationship is not perfect: cluster bands have been found without scalloped borders, and vice versa.

Table 1. Percent of Canine Teeth With One or More Defects of Different Types.

	Percent (n)
Any Surface Defect	80.4 (37)
Enamel Opacity	10.9 (5)
Clear LEH	39.1 (18)
Mild LEH	19.6 (9)
Any LEH	47.8 (22)
Single Pit	8.7 (4)
Pit Patch	41.3 (19)
Clear LEH or Pit Patch	65.2 (30)
Histological Defects	
Accentuated Stria of Retzius	37.0 (17)
Cluster Band	37.0 (17)
Wilson Band	17.4 (8)
Wilson or Cluster Band	45.7 (21)

Table 2. Frequency of enamel hypoplasias by type and age at development; total sample (n = 46).

	Light Line	LEH	Pit Patch	Pit	Pits+Lines	TOTAL
DEVELOPMENTAL AGE						
nb - 0.5	0.0	0.0	0.0	0.0	0.0	0.0
0.5 - 1.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0 - 1.5	0.0	0.0	0.0	0.0	0.0	0.0
1.5 - 2.0	4.0	0.0	4.0	0.0	4.0	8.0
2.0 - 2.5	6.1	0.0	3.0	0.0	3.0	9.1
2.5 - 3.0	5.6	5.6	5.6	0.0	10.2	16.8
3.0 - 3.5	12.5	0.0	12.5	5.0	17.5	30.0
3.5 - 4.0	9.1	6.8	20.5	2.3	29.6	38.6
4.0 - 4.5	6.8	15.9	20.5	4.5	40.9	47.7
4.5 - 5.0	0.0	15.9	27.3	6.8	50.0	50.0
5.0 - 5.5	2.5	12.5	15.0	5.0	32.5	35.0
5.5 - 6.0	0.0	7.9	10.5	0.0	18.4	18.4
6.0 - 6.5	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. Frequency (p
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DEVELOPMENTAL
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2.5 - 3.0
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* Labial only = a stria of Retzi

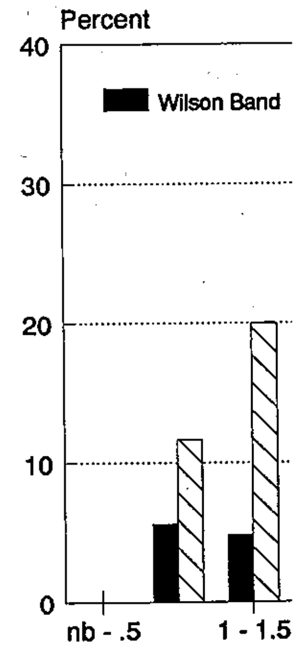

Figure 4. The chronologic
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t development; total

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0.0	0.0
0.0	0.0
0.0	0.0
4.0	8.0
3.0	9.1
10.2	16.8
17.5	30.0
29.6	38.6
40.9	47.7
50.0	50.0
32.5	35.0
18.4	18.4
0.0	0.0

Table 3. Frequency (percent) of histological defects by type and age at development; total sample (n = 46).

	Labial Only*	Wilson Band	Cluster Band	Wilson or Cluster	TOTAL
DEVELOPMENTAL AGE					
nb - 0.5	0.0	0.0	0.0	0.0	0.0
0.5 - 1.0	0.0	5.6	11.7	17.3	17.3
1.0 - 1.5	9.5	4.8	20.0	24.8	39.1
1.5 - 2.0	11.5	0.0	20.0	20.0	31.5
2.0 - 2.5	17.6	5.8	24.2	30.0	47.6
2.5 - 3.0	5.4	10.8	22.2	33.0	38.4
3.0 - 3.5	9.8	2.4	25.0	27.4	37.2
3.5 - 4.0	2.2	4.4	25.0	29.4	31.6
4.0 - 4.5	11.1	2.2	31.8	34.0	45.1
4.5 - 5.0	0.0	6.7	27.2	33.9	33.9
5.0 - 5.5	0.0	2.4	35.0	37.4	37.4
5.5 - 6.0	0.0	0.0	23.6	23.6	23.6
6.0 - 6.5	0.0	0.0	20.6	20.6	20.6

* Labial only = a stria of Retzius that extends from near surface to DEJ, but could be seen only on the labial side.

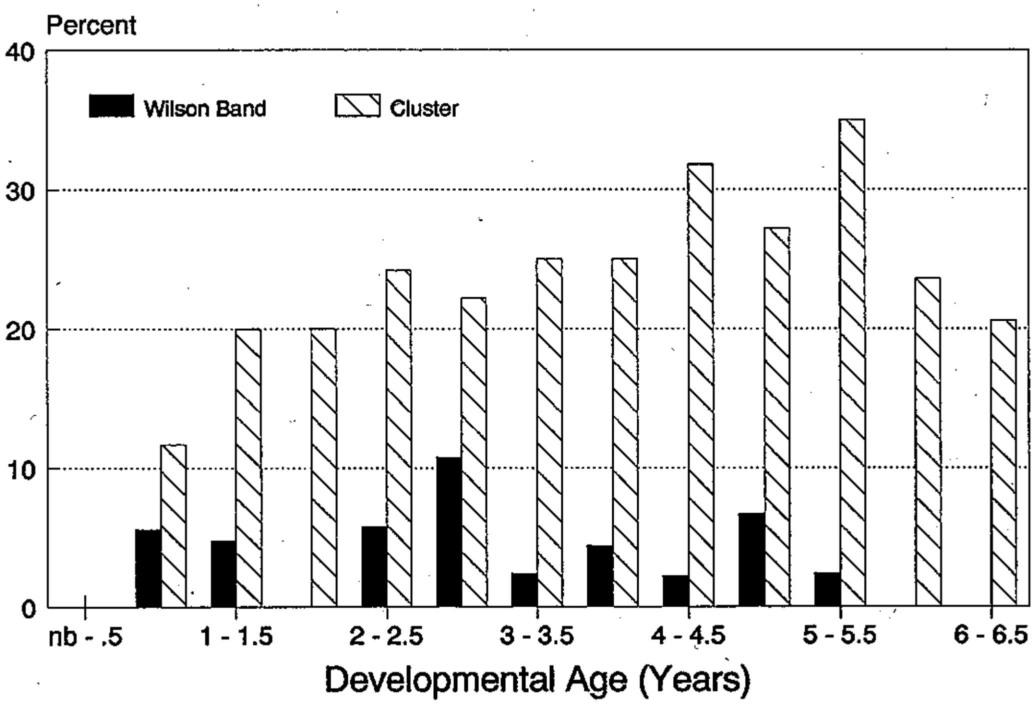

Figure 4. The chronological pattern of formation of Wilson bands and cluster bands on Black Mesa Anasazi permanent canines.

Table 4. Association Between Surface and Histological Defects.

	Wilson Band	Cluster Band
No Surface Defect	2 (80%)	1 (6.25%)
Opacity	1 (10%)	1 (6.25%)
LEH	1 (10%)	3 (18.75%)
Pit Patch	5 (50%)	9 (56.25%)
Pit Patch and LEH	1 (10%)	2 (12.50%)
Pit Patch or LEH	7 (70%)	14 (87.50%)

Association of Surface and Histological Defects.

Both Wilson bands and cluster bands are frequently associated with a surface defect. Of the ten Wilson bands found without a cluster band, seven (70%) were associated with either a LEH or pit patch, and an additional Wilson band (10%) was associated with an opacity (Table 4). Most often, Wilson bands were found associated with a pit patch (50%). Only in one case was a Wilson band associated with a clear LEH.

Of the sixteen cluster bands found without an embedded Wilson band, 14 (87.5%) were associated with an LEH or pit patch (Table 4). As with the Wilson bands, cluster bands tend to be found more often in association with pit patches than with any other type of surface defect.

Discussion.

Enamel Surface Defects.

Our experience suggests that enamel surface defects are rarely as unambiguous as the examples used for classification (FDI, 1982). For example, linear enamel hypoplasias in the Black Mesa, as well as other prehistoric populations, tend to be less severe and display great variation in width and depth (Goodman and Rose, 1990). It is possible that more severe defects are infrequently noted in prehistoric groups because individuals were not likely to have survived if they were physiologically challenged to such a demanding degree that ameloblasts were severely compromised. This differential survivability may, of course, also explain why so few defects are typically found in the earlier developing portion of canines and incisors.

In addition to rather typical and continuous variation in the width and depth of linear enamel defects, the classification of hypoplastic defects as either lines or pits, dating back to the earliest work of Sarnat & Schour (1941), may also be an over simplification. Pit patches, the most common form of enamel surface defect found on the Black Mesa canines, sometimes have a quasi-linear arrangement. Moreover, pit patches often incorporate a linear hypoplasia in combination with an irregular arrangement of pits.

The etiological and epidemiological significance of pits and pit patches has received little attention. From the perspective of ameloblastic function, the formation of a pit implies that a select group of ameloblasts, typically located near to the midline of the labial surface, slow in l Defects.

Cluster Band
1 (6.25%)
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3 (18.75%)
9 (56.25%)
2 (12.50%)
14 (87.50%)

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to rather typical and con- on in the width and depth iel defects, the classifica- stic defects as either lines back to the earliest work chour (1941), may also be ification. Pit patches, the form of enamel surface n the Black Mesa canines, ve a quasi-linear arrange- er, pit patches often incor- r hypoplasia in combina- rregular arrangement of

gical and epidemiological f pits and pit patches has attention. From the per- eloblastic function, the for- implies that a select group , typically located near to the labial surface, slow in their secretion of enamel matrix. This slowing of matrix formation leads to thinner enamel, and a surface indentation, or pit. What is fascinating and yet to be explained concerns why only select members of a cohort of secretory ameloblasts would be disrupted. The fact that a condition arrests some but not all ameloblasts might indicate a less severe disruption than one that involves all ameloblasts. In fact, however, LEHs are often observed to occur only on the labial surface, with the depth of the defect decreasing near the interproximal borders. Thus, even in most typical examples of LEH, there is evidence that not all ameloblasts in a cohort are similarly disrupted.

We suggest that pit patches may indicate periods of chronic physiological disruption. Ameloblasts are seemingly at the threshold of full recovery and function. They may waiver at this threshold, sporadically passing over it. This developmental interpretation fits with archaeological and paleoepidemiological data on Black Mesa; 87% of individuals showed signs of chronic anemia and 62% show evidence of anemia co-occuring with chronic infactions (Martin & al., 1991).

Histological Defects.

The low frequency of teeth (n = 8, 17.4%) with unambiguous Wilson bands might suggest that Black Mesa individuals experienced little physiological disruption during the time of permanent canine crown formation. However, seventeen teeth (37.0%) also display one or more cluster bands.

That nearly two thirds of histological defects are cluster bands, and most accentuated stria of Retzius are not associated with prism bending, further suggests that stress on Black Mesa was more chronic than acute. Similar to the proposition that pit patches signify chronic stress, we propose that cluster bands as well are indicative of chronic stress. In essence, we propose that prism bending is not always a necessary criteria for histological confirmation of systemic physiological disruption.

Cluster bands are often associated with hypoplastic defects, either pits or LEHs. Furthermore, nearly two thirds of cluster bands were also found in conjunction with scalloped bordered DEJs. Sometimes the association is uncanny: clustering correlates perfectly with scalloping. However, clustering is found without scalloping and we have also observed scalloped border DEJs without clustering. The mechanism by which scalloped borders develop has, to our knowledge, never been evaluated.

Recommended Research Directions.

Further research is called for regarding the etiological significance of pit patches and cluster bands. Both phenomena have barely been recognized in the scientific literature. Cluster bands have recently been noted in the laboratory of Dr. Jerome Rose (Goodman & Rose 1990). Whereas defects similar to the phenomena of our pit patches have frequently been noted, their meaning has never been systematically assessed. An interesting and perhaps instructive parallel may be found in Skinner and Hung's (1989) consideration of a localized enamel surface hypoplasia on deciduous canines.

At this time we have little information on the epidemiology of these defects in contemporany populations. The proposition that pit patches and cluster bands are manifestations of chronic physiological perturbation requires further confirmation. As well, it is hoped that other studies will quantify the association of cluster band and irregular DEJs, and the association between surface and histological defects. More fundamentally, further research is required into the precise nature of the response of enamel to perturbations. The proposition that enamel only responds in a single, stereotypic fashion — ameloblasts either secrete enamel or do not — may require revision.

It is fortunate that few populations likely suffer from physiological perturbations to a degree that severe LEH is highly prevalent (Enwonwu, 1973; Goodman & al., 1987, 1991). Thus, the relationship of severe stress to severe hypoplasia may be of only limited utility. What may have greater public health significance is the delimitation of the meaning of less severe forms of enamel disruption. However, the etiology of these less severe defects may be more complex. Ultimately this research leads back to fundamental questions about the nature of normal enamel development and the boundaries between normal and disordered enamel.

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References.

Clarkson, J., 1989, Review of terminology, classification, and indices of developmental defects of enamel. *Adv. Dent. Res.* 3(2): 104-109.

Condon, K., 1981, Correspondence of developmental enamel defects between the mandibular canine and the first molar. *Unpublished M.A. Thesis*, University of Arkansas, Fayetteville.

Dean, J.S., 1988, Dendrochronology and Paleoenvironmental Reconstruction on the Colorado Plateaus. In *The Anasazi in a Changing Environment*, edited by G.J. Gumerman, pp. 119-167. Cambridge University Press, Cambridge.

Ford, R.I., 1984, Ecological Consequences of Early Agriculture in the Southwest. In *Papers on the Archaeology of Black Mesa, Arizona*, vol. II, edited by S. Plog and S. Powell, pp. 127-138. Southern Illinois University Press, Carbondale.

Enwonwu C.O., 1973, Influence of socio-economic conditions on dental development in Nigerian children. *Arch. Oral Biol.* **18:** 95-107.

Federation Dentaire International, 1982, An epidemiological index of developmental defects of dental enamel (DDE Index) *Int. Dent. J.* 32(2): 159-167.

Goodman, A.H., Allen, L.H., Hernandez, G.P., Amador, A., Arriola L.V., Chavez, A. & Pelto, G.H., 1987, Prevalence and age at development of enamel hypoplasias in Mexican children. *Am. J. Phys. Anthropol.* **72:** 7-19.

Goodman, A.H. & Armelagos, G.J., 1985, Factors affecting the distribution of enamel hypoplasias within the human permanent dentition. *Am. J. Phys. Anthropol.* **68:** 479-93.

Goodman, A.H., Martinez, C. & Chavez, A., 1991, Nutritional supplementation and the development of linear enamel hypoplasia in children from Tezonteopan, Mexico. *Am. J. Clin. Nutr.* **53:** 773-781.

Goodman, A.H. & Rose, J.C., 1990, Assessment of systemic physiological perturbations from dental enamel hypoplasia and associated histological structures. *Yearbook of Physical Anthropology* **33:** 59-110.

Gumerman, G.J., 1984, *A View from Black Mesa: The Changing Face of Archaeology.* University of Arizona Press, Tucson.

Gumerman, G.J., 1988, A H
on Environment and Cultur
In *The Anasazi in a Changin*
ed by G.J. Gumerman,
University Press, Cambrid

Karhu, S., 1991, Childhoo
histopathologies in a Medie
Population. *Unpublished*
University of Colorado, Bo

Kreshover, S.J., 1960, Met
tooth formation. *Ann.*
85: 161-167.

Martin, D.L., Goodman, A.
Magennis, A.L., 1991,
Health: Reconstructing L
Death and Disease. Center
vestigations, Carbondale,

Massler, M., Schour, I. & Po
velopmental pattern of th
the calcification pattern of
Child. **62:** 33-67.

Mensforth, R.P., Lovejoy,
melagos, G.J., 1978, The ro
tors, diet and infectious d
of porotic hyperostosis an
in prehistoric infants and
thropol. **2:** 1-59.

Dollege. The authors also wish
n and Eric Goodman for help

Review of terminology, clas-
s of developmental defects of
Res. 3(2): 104-109.

rrespondence of developmen-
tween the mandibular canine
. *Unpublished M.A. Thesis,*
ısas, Fayetteville.

ndrochronology and Paleoen-
struction on the Colorado
ısazi in a Changing Environ-
J. Gumerman, pp. 119-167.
ty Press, Cambridge.

logical Consequences of Ear-
Southwest. In *Papers on the*
; Mesa, Arizona, vol. II, edit-
Powell, pp. 127-138. Southern
ress, Carbondale.

, Influence of socio-economic
development in Nigerian chil-
ol. **18:** 95-107.

e International, 1982, An
x of developmental defects of
DE Index) *Int. Dent. J.*

len, L.H., Hernandez, G.P.,
ı L.V., Chavez, A. & Pelto,
nce and age at development
as in Mexican children. *Am.*
72: 7-19.

rmelagos, G.J., 1985, Factors
ution of enamel hypoplasias
ermanent dentition. *Am. J.*
: 479-93.

tinez, C. & Chavez, A., 1991,
entation and the development
ypoplasia in children from
ico. *Am. J. Clin. Nutr.*

ose, J.C., 1990, Assessment
gical perturbations from den-
a and associated histological
k of Physical Anthropology

84, *A View from Black Mesa:*
of Archaeology. University of
son.

Gumerman, G.J., 1988, A Historical Perspective on Environment and Culture in Anasazi Country. In *The Anasazi in a Changing Environment*, edited by G.J. Gumerman, pp. 1-24. Cambridge University Press, Cambridge.

Karhu, S., 1991, Childhood stress and dental histopathologies in a Medieval Christian Nubian Population. *Unpublished Ph. D. Dissertation,* University of Colorado, Boulder.

Kreshover, S.J., 1960, Metabolic disturbances in tooth formation. *Ann. N.Y. Acad. Sci.* **85:** 161-167.

Martin, D.L., Goodman, A.H., Armelagos, G.J. & Magennis, A.L., 1991, *Black Mesa Anasazi Health: Reconstructing Life from Patterns of Death and Disease.* Center for Archaeological Investigations, Carbondale, Ill.

Massler, M., Schour, I. & Poncher, H.G., 1941, Developmental pattern of the child as reflected in the calcification pattern of the teeth. *Am. J. Dis. Child.* **62:** 33-67.

Mensforth, R.P., Lovejoy, C.O., Lallo, J.W. & Armelagos, G.J., 1978, The role of constitutional factors, diet and infectious disease on the etiology of porotic hyperostosis and periosteal reactions in prehistoric infants and children. *Medical Anthropol.* **2:** 1-59.

Powell, S., 1983, *Mobility and Adaptation: The Anasazi of Black Mesa, Arizona.* Southern Illinois University Press, Carbondale.

Powell, S., Andrews, P.O., Nichols, D. & Smiley, F.E., 1983, Fifteen Years on the Rock: Archaeological Research, Administration and Compliance on Black Mesa, Arizona. *American Antiquity* **48:** 228-252.

Rose, J.C., 1979, Morphological variations of enamel prisms within abnormal striae of Retzius. *Hum. Biol.* **51:** 139-151.

Sarnat, B.G. & Schour, I., 1941, Enamel hypoplasias (chronologic enamel aplasia) in relation to systemic diseases: a chronological, morphological and etiological classification. *J. Am. Dent. Assoc.* **28:** 1989-2000.

Skinner, M.F., & Hung, J.T.W., 1989, Social and biological correlates of localized enamel hypoplasia of the human deciduous canine tooth. *Am. J. Phys. Anthropol.* **79:** 159-175.

Suckling, G., 1989, Developmental defects of enamel — historical and present day perspectives of their pathogenesis. *Adv. Dent. Res.* **3:** 87-94.

Sweeney E.A., Saffir, J.A. & de Leon R., 1971, Linear enamel hypoplasia of deciduous incisor teeth in malnourished children. *Am. J. Clin. Nutr.* **24:** 29-31.

Weiss, K.M., 1973, Demographic Models for Anthropology. *American Antiquity* **38:** 1-86.