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A QUANTITATIVE ANALYSIS OF THE NUMERICAL DENSITY AND THE DISTRIBUTIONAL PATTERN OF PRISMS AND AMELOBLASTS IN DENTAL ENAMEL AND TOOTH GERMS

V. PRISM DENSITY AND PATTERN ON THE OUTER AND INNER SURFACE OF THE ENAMEL MANTLE OF CANINES

by
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INTRODUCTION

Several investigators have compared prism diameters on the inner and outer enamel surfaces, sometimes in unspecified zones of the enamel. They have arrived at different conclusions concerning the ratio between the mean prism diameters on the inner and outer surfaces in such zones. In the literature there are also conflicting opinions concerning the ratio between the total number of prisms on the outer surface and the total number on the inner surface.

Von Ebner (1899) maintained that every prism rod runs unbroken from the inner to the outer enamel surface.

Pickerill (1913) tried to compare prism diameters on the inner and outer enamel surfaces with the areas of these surfaces. He stated that he had measured prism diameters on both surfaces of a great number of teeth. The measurements were conducted on the buccal surface of human teeth. He fond a mean prism diameter of 3.1 μ at the dentinoenamel junction and a mean diameter of 5.7 μ on the outer surface. The ratio between these two values was 1:1.83.

He then measured the length of the amelodentinal junction from the cemento-enamel junction to the apex of the dentinal cusp, and the corresponding length from the cemento-enamel junction to the apex of the enamel cusp on the outer surface. The ratio between these lengths was 1:1.76.

Pickerill stated further, that the difference between prism diameters on the inner and outer enamel surfaces was particularly great in the cuspal zone. In this zone his means were 2.5 μ on the inner and 6.5 μ on the outer surface. *Pickerill's* measurements were conducted on longitudinal tooth sections. He concluded that the centrifugal growth of prism diameters is a sufficient compensation for the difference in area between the inner and outer enamel surfaces.

Dewey (1914) was of the opinion that the total number of prisms on the outer surface is higher than the total number on the inner surface.

Lewis and *Stöhr* (1914) believed that the difference in area between the inner and outer surface is partly compensated by a faint growth of the individual prisms centrifugally, but also by supplementary prisms on the outer surface.

Mummery (1919) had observed prism rods that furcated towards the outer surface. According to his opinion such furcations were the origins of supplementary prisms.

Andrews (1919) refuted *Pickerill's* conclusions, since he himself had seen many supplementary prisms in developing enamel. He had counted 19 prisms within a given area near the amelodentinal junction and 24 prisms within an area of the same extent near the outer enamel surface. He concluded from this experiment that supplementary prisms exist on the outer surface.

Noyes and *Thomas* (1921) stated that the prism rods were of the same diameter at the outer and inner ends. Apart from the existence of supplementary prisms on the outer enamel surface, Noyes asserted that a surface expansion came into existence since the prism rods were seldom perpendicularly orientated to the outer surface.

Broomell and *Fischelis* (1922) supported the theory of supplementary prisms.

Chase (1924) stated that the prevailing contemporary belief was that the difference in area between outer and inner surfaces was compensated by supplementary prisms on the outer surface. In the same paper he published results that were contradictory to this view. In his investigations he had used 20 μ thick ground sections of human teeth which were cut in the transversal, labio-lingual and mesio-distal planes. In one experiment Chase applied a modification of Pickerill's method. He counted the number of prisms along a certain distance parallel to the outer and inner surfaces. From the resultant values he calculated a mean prism diameter for each surface. In the same region where such countings had been carried out, he measured the lengths of the amelodentinal junction and of the outer enamel circumference. The ratio between these lengths was then compared with the ratio between the mean prism diameters of the inner and outer enamel surfaces. The latter ratio equalled 1:1.23, while the ratio between the lengths of the inner and outer circumferences equalled 1:1.27. Chase made it clear that the interprismatic substance had been included in the measurements of the prism diameters.

Chase's second method was a direct count of longitudinally sectioned prisms along the outer and inner borders of the enamel in transversal ground sections where the enamel had been »segmented» by cracks parallel to the prism directions. In each segment the prisms were counted along the inner and outer enamel borders. For each segment Chase found that the numbers were practically equal. He concluded that there are no supplementary prisms on the outer enamel surface, and that the difference in area between the inner and outer surfaces is mainly compensated by the centrifugal growth of the prism diameters.

His reservations was, however, that to a lesser degree the difference in area is caused by the angle between the prism rods and the outer surface, while the rods run perpendicularly from the inner surface. He concluded also that the interprismatic substance does not contribute to the growth of the area.

Hopewell-Smith (1926) contended that there are supplementary prisms on the outer surface.

Yosida (1938) measured prisms diameters on a high number of human and animal teeth on both enamel surfaces. His measurements were conducted in a cervical and a cuspal zone. He concluded that the prism diameters in the cervical zone are generally greater than in the cuspal zone. He concluded further that the prism diameters are generally greater on the outer than on the inner surface.

Süss (1939) developed a method to determine the ratio between the areas of the inner and the outer enamel surfaces of one tooth. He applied his method to a dog's canine and found a ratio of 1:1.31. He did not, however, try to calculate the number of prisms on these surfaces, but stated that he had not observed any difference in prism diameters. He contended that the curvature of prism rods sufficiently compensated for the difference in area.

Wolf (1942) agreed with Süss that there is no difference in prism diameter on the inner and outer enamel surfaces, but did not accept his theory of prism deflections as the cause of the centrifugal increase of surface area, pointing out that the course of the prism rods is quite perpendicular to the outer surface. Instead he presented his »Umreihungstheorie», which said that the centrifugal increase of the enamel surface is caused by a transversal shifting of prism layers during amelogenesis.

Quigley (1959) did not find any difference in diameter between prisms on the outer and inner surfaces of developing enamel by his electron-microscopical studies.

Fosse (1964) tried to calculate the total number of prisms on the outer and inner enamel surfaces of one tooth by measuring the surface areas, and by counting the linear number of prisms in numerous places. The results from two teeth were presented. The same method was later applied to a third specimen, a bicuspid, the data from which will be included in this survey. All specimens were human permanent teeth.

The 1st was a peg-shaped incisor. The calculated mean number of prisms per unit area on the outer surface was 29,584/mm² and on the inner surface 51,529/mm².

The 2nd specimen was a normal bicuspid. The mean number of prisms on its outer surface was 21,904/mm², and on the inner 47,089/mm².

For the third specimen, also a normal bicuspid, was calculated 19,880/mm² on the outer surface, and 44,520/mm² on the inner surface.

In each of these three experiments the author found that the calculated total number of prisms on the inner surface exceeded the calculated number on the outer surface by approximately 10 %.

Among the authors quoted above only Pickerill, Chase and Fosse actually tried to define the ratio between the total number of prisms on the outer surface and the total number of prisms on the inner surface of one given tooth. The results of these three authors indicated that there are no supplementary prisms on the outer surface, and that the centrifugal increase of prism diameters is a sufficient compensation for the difference in area between the outer and inner enamel surfaces.

In part IV the present author described the variation in the number of prisms per unit area, or prism density, on the outer enamel surface of one tooth, and compared the results for specific regions with other teeth of the same type. The results indicated that the prism density varied with the thickness and curvature of the enamel. This might be expected if the number of prisms on the outer surface equalled the number of prisms on the inner surface, and if the prism density on the inner surface was fairly constant.

Since neither of the latter assumptions has been proven, it seemed desirable to compare the densities on the inner and outer surfaces of one tooth in definite zones of the enamel, and to compare prism densities in different regions on the inner surface of one and the same tooth.

By means of the method described in part III, the author intended to establish if the numerical prism density were lower on the outer than on the inner enamel surface of one tooth in places where there had been an actual local growth of enamel surface during amelogenesis and if, on the other hand, the prism densities were relatively equal on the two surfaces in places where no surface growth had occurred.

It was also the object to find out if the vertical compression of the prism pattern demonstrated on the outer enamel surface (cf. part IV) were absent on the inner enamel surface.

Furthermore it seemed desirable to know whether the local variation in prism size found on the outer enamel surface were greater or smaller on the inner enamel surface.

The final aim was to establish if there were a significant difference between prism densities in different regions on the inner enamel surface.

MATERIAL

In part IV the author described the prism densities in specific regions on the outer enamel surface of 4 maxillary human permanent canines. These teeth were designated by the symbols C_1, C_2, C_3 and C_4.

For the study to be described in this paper C_1 and C_4 were selected together with a third seemingly normal human permanent maxillary canine not included in the study described in part IV. A young dog's maxillary permanent canine was included in the present study. This latter specimen will henceforth be designated by C_c.

METHODS

The calculation of prism density, pattern and diameters

In part III the author described his method of expressing the number of cross sectioned prisms per unit area, their distributional pattern and their diameters by measuring the central distances between pairs of adjacent prisms within photographed enamel regions of a given area. In the present investigation the constant area of the regions was 26,817 μ^2.

He demonstrated that the prism density could be represented by three slightly different expressions, each based upon a particular method of calculation and symbolized by a_{dyx}, a_{reg} and $\langle a_{gr} \rangle$. In this paper only one of them will be used in graphs and in statistical comparisons between regional prism densities. This expression is a mean value and is symbolized by $\langle a_{gr} \rangle$. The standard deviation is written S_{agr}.

In the tables of this paper the prism density of each region is expressed by the $\langle a_{gr} \rangle$-value and, as a control, also by the a_{reg}-value. The a_{reg}-values have been included since they are probably better estimates of the true regional prism densities, and since they correspond more truly to the ⟨D⟩-values, or the mean regional central distances.

The numbers of measured triangles and plotted prism groups in each region have been included in the tables. The tables also present the mean regional compression ratio ⟨K⟩ and the standard deviation S_K. Also included are the mean regional central distances ⟨D⟩ and the standard deviation S_D. ⟨D⟩ means prism diameter under certain assumptions, (cf. part III).

Marking and orientation of depth series

In the Gillings sectioning machine a $600\,\mu$ thick section in the median labio-lingual plane was cut from each human tooth. Each section was embedded in a plastic column with one of its cut surfaces in the upper surface of the column (cf. parts I and II).

Fig. 1 is a photographic representation of the embedded median section of C_1. It is perhaps possible to discern the four straight lines engraved in the enamel. Each of these lines follows the main prism direction in its area. This is better demonstrated by Fig. 2 which represents the area of the gingivo-labial line in Fig. 1 with a higher magnification.

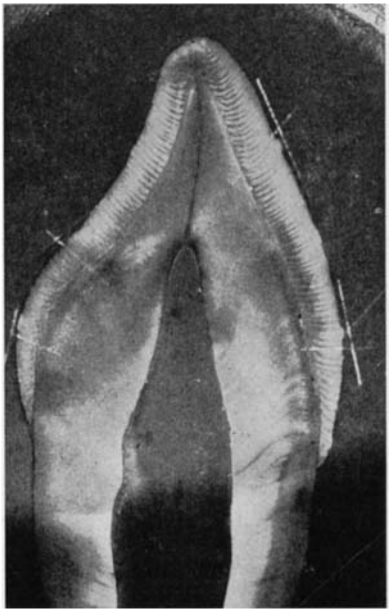

Fig. 1. The labio-lingual, median section of C_1, a human permanent canine, embedded in a plastic column. In four positions defined in the text have been ruled straight lines following the main prism course. These lines are called guide lines.

Fig. 2. The gingivolabial guide line in the median section of C_1, with a higher magnification. This area is called position 2 in the text.

The lines engraved in the prism directions will henceforth be called guide lines. They cross the outer enamel surface in positions that approximately correspond to regions 2, 7, 13 and 15, whose sites have been defined by this author in part IV. Consequently the 4 enamel areas will henceforth be called position 2, position 7 and so forth.

The permanent canine of a dog is morphologically quite different from a human canine. Its crown is curved distally so that the nearest approximation to a plane of symmetry is orientated in a mesio-distal direction. Accordingly C_c has been cut in this plane. For this reason the regions numbered 2, 7, 13 and 15 are not situated on the labial and palatinal surfaces of C_c. However, their positions relative to the cemento-enamel junction and the tip of the crown correspond to the definition given for the human permanent canines (cf. part IV).

Fig. 3 represents the section of C_c and may demonstrate that the lines which follow the prism course are nearly perpendicular to the amelodentinal junction.

In the plastic surrounding the sections of C_1, C_4 and C_c was engraved, across each guide line, a short line parallel to the amelodentinal junction

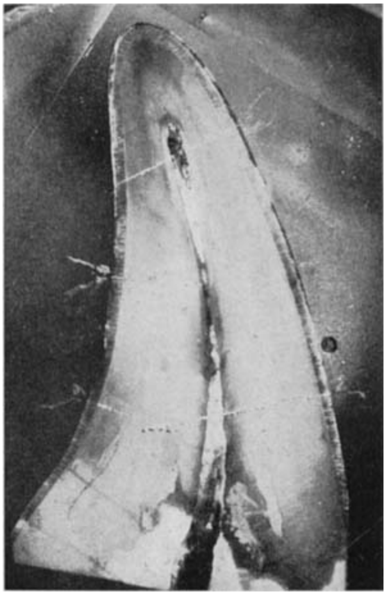

Fig. 3. The mesio-distal section of C_c, a dog's permanent canine, embedded in a plastic column. The 4 guide lines following the main prism directions are nearly perpendicular to the amelodentinal junction and the outer enamel surface.

where the latter was crossed by the guide line. These lines will be called tangent lines.

From each position a series of planoparallel surfaces was to be ground towards the amelodentinal junction. The ground surfaces were to be perpendicular to the median section plane and parallel to the tangent line. The guide line was intended to serve as a reference point while photographing a section of each ground surface.

The engraving of visible reference lines in dental enamel

Fig. 4 is a photographic representation of the 25× objective of the microscope. The letter A designates a riffled brass ring fitted to the front tube of the telescopic objective. The brass ring carries a small pointed diamond in its cylindrical setting, designated by the letter B. The brass ring is provided with two small set screws, not visible in the photograph. One of the set

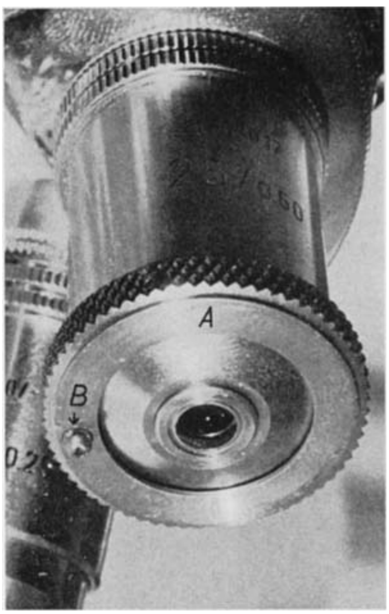

Fig. 4. The 25× Leitz telescopic objective provided with a brass ring designated by the letter A. The letter B designates the cylindrical setting of a diamond point. The brass ring is locked to the front tube of the objective. When the objective is lowered below the focal plane, the diamond point is resting on the object with a pressure equal to the weight of the front tube and the brass ring, since the internal extension spring of the objective has been removed. A straight line is thus engraved in the object when the stage is shifted.

screws serves to lock the ring to the front tube. The second set screw serves to lock the cylindrical setting of the diamond at the desired height over the object. This height corresponds to a position where the point of the diamond is suspended midway between the upper surface of the object and the front of the objective when in focus.

To engrave a line in a given direction and position on the enamel surface, the plastic column was rotated on a stage so that the desired direction coincided with one of the two main directions of stage movement. The column was then locked in this position on the slide by Kerr resin. The stage was raised so that the diamond point was resting on the object. The pressure was equal to the weight of the front tube with the brass ring, since the extension spring within the objective had been removed. The stage was shifted in the desired direction a distance indicated by the corresponding stage microcator (see Fig. 1, part II). Previously the brass ring had been adjusted so that the engraved line would pass through the center of the optical field. The horizontal distance between the point of the diamond and the optical center was known and had to be taken into consideration.

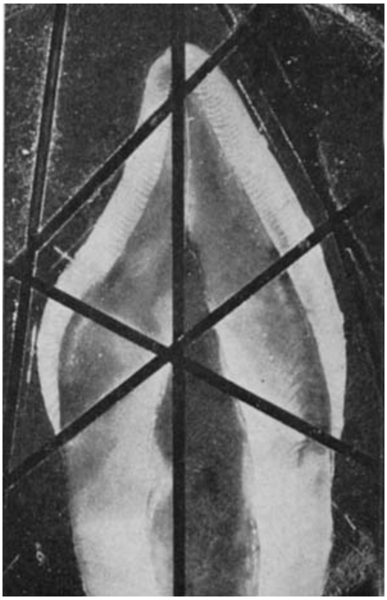

Fig. 5. The median section of C_1 in the plastic column after the sectioning along the tangent lines. The tangent lines are parallel with the amelodentinal junction in the positions where the latter is crossed by the guide lines. In addition to the tangential sectioning, the specimen is sectioned along three central partition lines to separate the 4 positions.

Preparation of the 4 depth series

The rectangular plastic object carrier of the Gillings sectioning machine was placed like an ordinary slide on the stage of the microscope. The plastic column was placed with its flat base on the carrier. The column was then rotated so that one of the four tangent lines was directed 90° to the lateral stage movement. The tangent line would thus coincide with the feeding direction of the sectioning machine. In this position the column was locked by Kerr resin to the carrier, and sectioned along the tangent line perpendicularly to the upper surface. This procedure was repeated for all 4 areas.

Fig. 5 is a photographic representation of the median section of C_1, after the sectioning along the tangent lines had been carried out. The column was also cut along three partition lines, separating the 4 sectors. The depth of all cuts was half the height of the column.

By means of the stage microcators, the perpendicular distance between the tangential cut and the point of intersection between the guide line and the amelodentinal junction was measured in each area.

The final separation of the 4 sectors of enamel including positions 2, 7, 13 and 15 was carried out by sectioning the column along a plane which was planoparallel to the upper surface. The distance between the upper surface and the latter section plane was 5 mm.

Each of the resultant pieces was embedded in its own plastic column, the tangential section plane being in the upper surface of the new column. Thus the vertical distance from the upper surface to the point of intersection between the guide line and the amelodentinal junction was known.

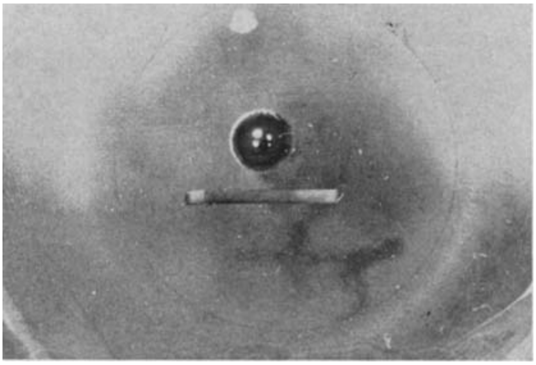

Fig. 6. The enamel sector of position 7 separated from the median section and embedded with the surface of the tangent section in the upper surface of the new plastic column. The spherical body is a steel ball used to weigh down the sector during the polymerization process.

Fig. 6 is a photographic representation of the piece with the enamel of position 7 in its plastic column. This photograph demonstrates the thickness of the original median section. The spherical body is a small iron ball serving to press down the section during the polymerization process.

The depth series of ground surfaces with an interproximate distance of 100 μ was prepared in the lapping machine constructed by this author and described in part I. Each ground enamel surface was etched by 5.2 % HNO_9 for 10 secs. and stained in Harris haematoxylin for 30 secs.

Microphotography of regions within the ground surfaces

The guide lines was seen as a faint indentation at the border of the ground and stained enamel surface. To facilitate recognition of the profile of the guide line in the first of a series of ground surfaces, its position on the outer enamel surface in relation to the extreme ends of the enamel sector had been determined prior to the final embedding. Each photomicrograph in a series was taken with the profile in a fixed position in the photographed area.

In Figs. 7 and 8 which represent the first and the last ground surfaces in the series of position 2 that starts from region 2 on C_1, the profile has been indicated by an arrow. Each ground surface was photographed with the Leitz Ultropak 22× objective.

RESULTS

The regional prism densities and patterns in the depth series

The first surface of each series was ground approximately 100 μ beneath the proper outer surface.

Figs. 7 and 8 are photographic representations of the first and last ground surfaces in the depth series in position 2 on C_1. This series consisted of 9 surfaces.

Figs. 9 and 10 represent the first and the last of 12 ground surfaces in the series in position 7.

In the same manner Figs. 11 and 12 represent the series in position 13, consisting of 10 surfaces, while Figs. 13 and 14 represent the series in position 15, consisting of 7 surfaces. In each series the interproximate distance between the ground surfaces was constantly 100 μ.

On C_4 and C_c was photographed the first ground surface in each position. Then the enamel was ground directly down to the amelodentinal junction and photographed. On these specimens, therefore, only the outer and inner enamel surfaces were represented for each region. Figs. 15 and 16 represent the outer and inner surfaces in position 2 on C_c. Figs. 17 and 18 represent the outer and inner surfaces in position 13 on C_c.

In Table I are listed the areg-, ⟨agr⟩-, Sagr-, ⟨K⟩- and ⟨D⟩-values for the depth series in position 2 on C_1 and the outer and inner enamel surfaces in the location of the same number on C_4 and C_c. The first column lists the depth from the outer enamel surface.

In Tables II, III and IV are listed the data of the series in positions 7, 13 and 15 on C_1, C_4 and C_c.

Figs. 19, 20, 21 and 22 are graphical representations of the ⟨agr⟩-values and their double standard deviations added and subtracted in the depth series in positions 2, 7, 13 and 15 on C_1.

Fig. 23 is a graphical representation of the prism densities on the outer and inner surfaces in the 4 positions on C_4.

In the same manner Fig. 24 represents the prism densities of C_c.

Testing of ⟨agr⟩-values in the depth series of C_1. Figs. 19, 20 and 22 representing positions 2, 7 and 15, demonstrate a gradual increase of prism density towards the amelodentinal junction.

According to Fig. 21 no such trend was demonstrable in the depth series in position 13.

Table I.

The prism density, the vertical compression of prism pattern and the central distances between adjacent prisms in series of ground surfaces towards the dentine in position 2 on two human permanent canines designated by C_1 and C_4, and one dog's permanent canine designated by C_c. On C_1 the surfaces constitute a continuous series towards the dentine. On C_4 and C_c the series are represented by the outer and the inner enamel surfaces only.

Specimen	Depth in μ	Triangles	Groups	Prisms/mm²			Vert. compr.		Central dist.	
				areg	⟨agr⟩	Sagr	⟨K⟩	S_K	⟨D⟩	S_D
	100	88	10	31520	31586	1965	1,26	0,29	6,03	0,40
	200	98	11	33167	32696	3202	1,16	0,21	5,88	0,40
	300	109	13	34800	35178	3027	1,24	0,23	5,74	0,40
	400	126	15	36554	37373	4335	1,24	0,22	5,60	0,46
C_1	500	139	15	39150	39047	3182	1,13	0,22	5,41	0,41
	600	153	17	40757	41258	3906	1,06	0,25	5,30	0,43
	700	169	17	42625	42278	4504	1,07	0,22	5,17	0,53
	800	126	15	47036	47509	5786	1,08	0,21	4,92	0,63
	900	64	10	44562	42788	5188	0,99	0,22	5,07	0,43
C_4	100	78	7	32081	32247	1354	1,39	0,20	5,98	0,33
	600	84	14	53686	55117	5179	1,02	0,19	4,61	0,40
C_c	100	73	10	29529	30778	4419	0,99	0,19	6,23	0,41
	300	69	10	32984	32870	2199	0,97	0,18	5,90	0,39

Table II.

The prism density, the vertical compression of prism pattern and the central distances between adjacent prisms in series of ground surfaces towards the dentine in position 7 on two human permanent canines designated by C_1 and C_4, and one dog's permanent canine designated by C_c. On C_1 the surfaces constitute a continuous series towards the dentine. On C_4 and C_c the series are represented by the outer and the inner enamel surfaces only.

Specimen	Depth in μ	Triangles	Groups	Prisms/mm²			Vert. compr.		Central dist.	
				a_{reg}	⟨a_{gr}⟩	S_{agr}	⟨K⟩	S_K	⟨D⟩	S_D
	100	99	10	24822	24962	1336	1,25	0,22	6,80	0,45
	200	76	11	25363	25900	4028	1,27	0,38	6,72	0,58
	300	100	9	27293	26882	4125	1,13	0,22	6,46	0,73
	400	141	11	28092	28238	965	1,10	0,21	6,39	0,45
	500	166	14	29455	29891	3024	1,04	0,23	6,24	0,49
C_1	600	105	13	28547	29497	5285	1,00	0,21	6,31	0,71
	700	77	9	29811	30438	4177	1,06	0,23	6,19	0,56
	800	108	14	32731	33424	4404	0,99	0,22	5,89	0,68
	900	144	14	36431	36214	3366	1,03	0,30	5,60	0,54
	1000	98	15	35568	35892	5902	1,05	0,35	5,66	0,58
	1100	150	14	38415	37733	4975	1,03	0,33	5,45	0,52
	1200	109	15	33277	36500	9185	1,13	0,44	5,82	0,89
C_4	100	68	7	21814	21711	1007	1,09	0,14	7,26	0,36
	1200	49	12	36606	37962	4361	1,06	0,37	5,58	0,56
C_c	100	49	8	27606	27888	1563	1,00	0,21	6,45	0,39
	400	57	8	35751	36378	2490	1,12	0,33	5,66	0,42

In each depth series of C_1 the ⟨a_{gr}⟩-values from the first and the last ground surfaces were t-tested against each other. If the confidence limit was set at 5 %, the t-test demonstrated that there was a significant difference between prism densities on the outer and inner enamel surfaces corresponding to positions 2, 7 and 15 on C_1, while the probability approximated 40 % that the densities on the outer and inner surfaces in position 13 represent the same universe.

On the inner enamel surface of C_1, the regional variation of prism size seems particularly great. Probably as a consequence of this the difference between a_{reg} and ⟨a_{gr}⟩ for one region is considerable. The ⟨a_{gr}⟩-value in these cases is greater than the a_{reg}-value. On the other hand the difference between the a_{reg}- and the a_{dyx}-values was not greater than on the outer enamel surface where the S_{agr}-values were small.

Table III.

The prism density, the vertical compression of prism pattern and the central distances between adjacent prisms in series of ground surfaces towards the dentine in position 13 on two human permanent canines designated by C_1 and C_4, and one dog's permanent canine designated by C_c. On C_1 the surfaces constitute a continuous series towards the dentine. On C_2 and C_c the series are represented by the outer and the inner enamel surfaces only.

Specimen	Depth in μ	Triangles	Groups	Prisms/mm²			Vert. compr.		Central dist.	
				areg	⟨agr⟩	Sagr	⟨K⟩	S_K	⟨D⟩	S_D
	100	75	9	33721	33667	1665	0,99	0,14	5,84	0,35
	200	90	13	36651	37532	2234	1,05	0,21	5,59	0,44
	300	130	17	35039	34908	2840	0,93	0,29	5,72	0,43
	400	83	12	31829	32392	2268	0,91	0,23	6,00	0,42
C_1	500	122	13	33163	34501	3543	0,90	0,30	5,88	0,48
	600	97	15	36823	38140	5694	1,06	0,40	5,56	0,66
	700	102	13	32572	33553	5396	0,89	0,26	5,90	0,73
	800	44	12	30425	34349	12276	1,26	0,65	6,07	1,03
	900	73	14	30091	39069	16827	1,04	0,35	6,07	1,19
	1000	33	8	28244	31057	7754	0,92	0,52	6,32	0,91
C_4	100	68	9	33729	33861	3849	0,99	0,16	5,82	0,49
	900	80	11	32167	33984	6314	1,05	0,22	5,94	0,71
C_c	100	46	10	26780	27569	3921	0,92	0,17	6,54	0,49
	300	62	11	51975	54470	7898	1,14	0,40	4,69	0,53

Since areg corresponds to ⟨D⟩, t-tests have been carried out between the ⟨D⟩-values of the outer and inner enamel surfaces in the four positions on C_1. The resultant P-intervals concerning positions 2, 7 and 15 were identical to those calculated for the ⟨agr⟩-values. Even in position 13, however, the P-value was smaller than 0,1 %.

Testing of ⟨K⟩-values in the depth series of C_1. Tables I, II and IV demonstrate a gradual decrease of the (K)-values in positions, 2, 7 and 15 towards the amelodentinal junction.

According to Table III no such trend was demonstrable in the depth series in position 13. It seems, however, that the ⟨K⟩-values approximate the value 1.00 and that they oscillate fairly symmetrically about this value.

If the confidence limit is set at 5 %, the t-test demonstrated that there was a significant difference between the compression ratios of the outer and inner surfaces in positions 2 and 7 ($P < 2.5$ %), while the probability of

Table IV.

The prism density, the vertical compression of prism pattern and the central distances between adjacent prisms in series of ground surfaces towards the dentine in position 15, on two human permanent canines designated by C_1 and C_4, and one dog's permanent canine designated by C_c. On C_1 the surfaces constitute a continuous series towards the dentine. On C_4 and C_c the series are represented by the outer and the inner enamel surfaces only.

Specimen	Depth in μ	Triangles	Groups	Prisms/mm²			Vert. compr.		Central dist.	
				a_{reg}	$\langle a_{gr} \rangle$	S_{agr}	$\langle K \rangle$	S_K	$\langle D \rangle$	S_D
	100	73	15	27552	28680	3264	1,28	0,19	6,46	0,40
	200	63	10	31978	32515	3466	1,28	0,19	5,98	0,50
	300	76	16	34115	34829	3585	1,27	0,25	5,80	0,40
C_1	400	104	17	37228	37480	3842	1,15	0,39	5,54	0,50
	500	87	16	36001	35925	3763	1,09	0,31	5,62	0,61
	600	30	8	54210	53660	6172	1,03	0,28	4,60	0,35
	700	22	7	60655	64975	10144	1,18	0,36	4,33	0,45
C_4	100	63	11	28800	28565	2182	1,30	0,28	6,31	0,49
	600	92	17	45812	46471	5901	1,01	0,28	5,00	0,44
C_c	100	46	8	22788	22634	1878	1,04	0,22	7,09	0,51
	300	62	11	42135	43053	4678	0,99	0,20	5,21	0,47

equality was high in position 13 ($P > 40$ %). Neither was the difference between the ratios in position 15 statistically acceptable ($P \approx 10$ %).

Testing of $\langle a_{gr} \rangle$-values on the outer and inner enamel surfaces of C_4. Fig. 23 demonstrates a marked difference between prism densities on the outer and inner enamel surfaces in positions 2, 7 and 15, whereas the difference between the $\langle a_{gr} \rangle$-values in position 13 is little.

A t-test demonstrated that the differences in positions 2, 7 and 15 were statistically significant, P being always less than 0.1 %. There was no significant difference in position 13, P being greater than 50 %. A t-test was also carried out for the $\langle D \rangle$-values of the outer and inner surfaces in the 4 positions and gave the same result as for the $\langle a_{gr} \rangle$-values.

Testing of $\langle K \rangle$-values on the outer and inner surface of C_4. Tables I, II and IV demonstrate markedly higher compression ratios on the outer than on the inner enamel surface in positions 2 and 15, whereas the differences are smaller in positions 7 and 13. In position 13, the compression ratio is even higher on the inner than on the outer enamel surface.

A t-test demonstrated that the differences were statistically significant in positions 2 and 15, whereas the differences in positions 7 and 13 were not.

Testing of $\langle a_{gr} \rangle$*-values on the outer and inner surfaces of* C_c. Fig. 24 demonstrates a marked difference between prism densities on the inner and outer surfaces in positions 7, 13 and 15, whereas the $\langle a_{gr} \rangle$-values in position 2 show a smaller difference. A t-test demonstrated that the differences concerning positions 7, 13 and 15 were statistically significant. There was not a statistically significant difference in position 2.

Testing of $\langle K \rangle$*-values on the outer and inner surfaces of* C_c. Tables I and IV demonstrate a small difference between the compression ratios in positions 2 and 15. The difference is greater in positions 7 and 13, but here the ratios on the inner surface are higher than the ratios on the outer.

There was no significant difference in positions 2 and 15. The difference was significant in positions 7 and 13.

Testing of difference between $\langle a_{gr} \rangle$*-values on the inner surfaces of* C_1, C_4 *and* C_c. The 4 $\langle a_{gr} \rangle$-values on the inner surface of each tooth are different. On C_1 they increase through the 4 positions in this sequence: 13, 7, 2 and 15. On C_4 they increase in this sequence: 13, 7, 15 and 2. On C_c they increase in this sequence: 2, 7, 15 and 13.

In Table V are presented the results of the testing of the difference between the densities in positions 2 and 7, while in Table VI are presented the results of a t-test between the positions 13 and 15 for all three specimens.

On C_1 there is no significant difference between the $\langle a_{gr} \rangle$-values of positions 2 and 7. The difference is significant for C_4 and C_c.

Table V.

t-test of difference between prism densities in positions 2 and 7 on the inner surface of C_1, C_4 *and* C_c, *designating two human and one dog's permanent canine.*

Specimen	Positions	Groups	Prisms/mm²		Probability
			$\langle a_{gr} \rangle$	S_{agr}	in %
C_1	2	10	42788	5188	$10 > P > 5$
	7	15	36500	9185	
C_4	2	14	55117	5179	$0,1 > P$
	7	12	37962	4361	
C_c	2	10	32870	2199	$1 > P > 0,5$
	7	8	36378	2490	

Table VI.

t-test of difference between prism densities in positions 15 and 13 on the inner surface of C_1, C_4 and C_c, designating two human and one dog's permanent canine.

Specimen	Positions	Groups	Prisms/mm^2 $\langle a_{gr} \rangle$	Prisms/mm^2 S_{agr}	Probability in %
C_1	15	7	64975	10144	0,1 > P
	13	8	31057	7754	
C	15	17	46471	5901	0,1 > P
	13	11	33984	6314	
C_c	15	11	43053	4678	0,1 > P
	13	11	54470	7898	

Table VII.

The prism density, the vertical compression of prism pattern and the central distances between adjacent prisms on the outer and inner enamel surfaces in positions 13 and 15 on a third human permanent canine.

Position	Surface	Triangles	Groups	Prisms/mm^{2}P			Vert. compr.		Central dist. in microns	
				a_{reg}	$\langle a_{gr} \rangle$	S_{agr}	$\langle K \rangle$	S_K	$\langle D \rangle$	S_D
13	Outer	72	7	31049	31511	1965	1,11	0,27	6,06	0,60
	Inner	60	13	29994	33547	6772	0,93	0,25	6,16	0,68
15	Outer	150	16	28978	29176	2242	1,28	0,33	6,29	0,44
	Inner	83	17	35851	39007	6186	1,02	0,24	5,65	0,53

For all three specimens the difference is significant between regions 13 and 15 on the inner enamel surface.

The $\langle a_{gr} \rangle$- and $\langle K \rangle$-values on the outer and inner enamel surfaces in positions 13 and 15 on a third human permanent canine. During the first stages of this investigation the present author prepared series of surface grindings towards the dentine in position 13 and 15 on a human maxillary permanent canine not included in the material presented in part IV.

In position 13 on this tooth the prism density was 31,511/mm^2 on the outer surface and 33,547/mm^2 on the inner surface. In position 15 the prism density was 29,176/mm^2 on the outer surface and 39,007/mm^2 on the inner surface.

The results from this tooth thus corroborated those from C_1 and C_4 concerning these two positions. Moreover, t-tests between the densities on the outer and inner surfaces resulted in $50 > P > 40$ for position 13 and $0.1 > P$ for position 15. t-tests carried out for the $\langle D \rangle$-values instead of the $\langle a_{gr} \rangle$-values in these positions gave the same results.

In position 13 $\langle K \rangle$ equalled 1.11 on the outer surface and 0.93 on the inner surface. In position 15 the ratios were 1.28 and 1.02 on the outer and inner surfaces respectively. The differences were statistically significant in both positions. Table VII presents the data from the outer and inner enamel surfaces in the two positions on this specimen.

DISCUSSION

Own findings

Prism density. It will be noticed that the number of groups and triangles varies from region to region. The pattern of group distribution was subjectively chosen for each region. But the object was always to cover the region evenly by numerous small groups of plotted prisms in a dense but random pattern rather than by a constant number in a given pattern.

On the inner enamel surface prism contours may not be discernible in smaller areas within the region. In some areas prism rods may lie in the ground plane for shorter distances. The presence of such areas disturbs the even distribution of the groups and thus also the number of them. When this occurs on the inner surface, where the variation of prism size is obviously greatest, the accuracy of the calculated regional prism density will probably suffer. But since only a fraction of the prisms within a region is plotted, the calculated density will always be but an estimate of the true regional density. It is probable that these estimates are better on the outer than on the inner enamel surface, however (cf. part III).

On C_1 the three depth series in positions 2, 7 and 15 demonstrated a gradual increase of prism density towards the amelodentinal junction, see Figs. 17, 18 and 20. Statistically, there was also a significant difference between the first and the last surfaces of these three series.

The depth series in position 13, however, showed neither a decrease nor an increase of density, see Fig. 19. A t-test between the $\langle a_{gr} \rangle$-values of the first and the last surfaces demonstrated no significant difference, whereas a t-test between the $\langle D \rangle$-values of the same surfaces demonstrated a significant difference.

The data gained from the outer and inner surfaces of C_4 generally seemed to corroborate the results concerning C_1, see Fig. 21. There was a significantly higher prism density on the inner surface in positions 2, 7 and 15, while no significant difference was demonstrable between the two surfaces in position 13.

The prism densities calculated for the outer and inner enamel surfaces in positions 13 and 15 on a third human maxillary permanent canine also corroborated the results concerning these positions on C_1 and C_4.

The data gained from the dog's canine demonstrated significantly higher prism densities on the inner surface in positions 7, 13 and 15, see Fig. 22, whereas the difference was not statistically acceptable in position 2.

The results concerning C_1, C_4 and the third human canine seemed to demonstrate that the prism density is lower on the outer than on the inner enamel surface in positions where there is a convex enamel curvature, and where consequently there has been a centrifugal growth of the enamel surface during amelogenesis. Position 13, however, was located in the flat portion of the palatinal surface, which might explain the lack of difference in prism density on the outer and inner enamel surfaces.

On the dog's canine, the enamel layer is generally far thinner than on human permanent canines. There is no flat portion of the enamel mantle. The enamel curvature is generally equal in all regions of the crown, except at the tip of the cusp.

In spite of the thinner enamel, the present investigation demonstrated a higher prism density on the inner enamel surface than on the outer surface of C_c.

Variation of prism density and diameters. Tables I, II, III and IV demonstrated that the variation of prism density within one region symbolized by S_{agr} generally increased towards the amelodentinal junction of C_1. The same trend seemed to be demonstrated by the SD values. The S_{agr}- and SD-values on the inner surface of C_4 were also higher than on the outer surface of the same tooth.

Tables V and VI demonstrated that there was a marked difference between the $\langle a_{gr} \rangle$-values for the 4 positions on the inner surface of C_1, C_4 and C_c. Thus there was a total surface variation of prism density on the inner surface of these three specimens.

Prism pattern. The $\langle K \rangle$-values in Tables I, II and IV seemed to indicate a gradually increasing vertical compression of the prism pattern from the dentinoenamel junction towards the outer surface in positions 2, 7 and 15 on C_1. In the depth series in position 13 no particular trend whatsoever was perceptible, see Table III. The $\langle K \rangle$-values oscillate near and about the value 1.00.

On C_4 the compression ratio was significantly higher on the outer than on the inner surface in positions 2 and 15, whereas the difference was not significant in positions 7 and 13.

It was demonstrated statistically that in positions 2,7 and 15 the prism densities were significantly lower on the outer enamel surface than on the inner surface on C_1 and C_4. In the same positions there was generally a significantly vertical compression of the prism pattern on the outer surface of these teeth.

In position 13, which corresponds to the flat central portion of the palatinal surface, there was no significant difference either between the $\langle a_{gr} \rangle$-values or the $\langle K \rangle$-values of the outer and the inner enamel surfaces of C_1 and C_4.

Therefore it seems that a vertical compression is present in places where a positive growth of the enamel surface during amelogenesis has taken place. This hypothesis was also supported by the compression ratios on the outer and inner surfaces in positions 13 and 15 on a third human permanent canine.

If each prism is formed by one ameloblast, the compression may be interpreted as a lateral distension of the ameloblastic layer during amelogenesis. Since there is little or no local growth of the enamel surface in the center of the palatinal surface of human permanent canines, the $\langle K \rangle$-values will approximate the value 1.00, which, according to definition, signifies the abscence of any vertical deformation.

In contrast to the results gained from C_1 and C_4, all the $\langle K \rangle$-values calculated for the outer enamel surface of C_c approximated the value 1.00. The two highest values 1.14 and 1.12 were found on the inner surface, in positions 7 and 13.

It would seem that the $\langle K \rangle$-values obtained from C_c do not demonstrate any systematic directional deformation of cross sectioned prisms.

If a compression ratio markedly greater than 1.00 is caused by a growth of the enamel surface, the results concerning C_c might be explained by the fact that the enamel of this tooth was far thinner than the enamel of C_1 and C_4, see Figs. 1 and 3. This is not a quite satisfactory explanation, however, since there was generally a marked and significant difference in prism density on the outer and inner enamel surfaces of C_c.

Comparison between results of other authors and own findings

If the total numbers of prisms on the outer and inner enamel surfaces were equal, and if it were possible to express a mean number of prisms per unit area for each of these two surfaces, then the ratio between the mean number on the inner surface and the mean number on the outer surface would be equal to the ratio between the area of the outer surface and the area of the inner enamel surface.

The sum of the four $\langle a_{gr} \rangle$-values on the inner surface was divided by the sum of the four $\langle a_{gr} \rangle$-values on the outer surface of C_1. The same calculation was carried out for C_4. The quotients were 1.47 and 1.49 respectively.

Fosse (1964) found a ratio of 1.9 between the areas of the outer and inner enamel surfaces of one bicuspid. It is probable that the ratio is less on a canine, due to the simpler form of the crown. However, it is not probable that the mean of the four $\langle a_{gr} \rangle$-values was representative of the »true mean» of each surface, since the approximal surfaces were not represented in this investigation.

The enamel mantle of a dog's canine is less complicated than the mantle of a human permanent canine. The transversal circumference is, on all levels, quite circular and the crown is evenly tapered from the cemento-enamel junction towards the tip of the cusp. Therefore it is possible that the ⟨agr⟩-values gathered from C_c were better estimates of the »true mean» prism densities on both surfaces of this tooth.

For C_c the ratio calculated from the $\langle a_{gr} \rangle$-values was 1.53. *Süss* (1939) had found a ratio of 1.31 between the outer and inner enamel surfaces of a dog's canine. He stated, however, that he had not observed any difference in prism diameters on the two surfaces.

The present author found that the prism densities on the outer surface of four human permanent canines indicated a tendency to be inversely proportional to enamel thickness and curvature (cf. part IV). The findings presented in the present paper seem to corroborate this hypothesis, since the depth series of C_1 demonstrated a gradual decrease in density towards the outer surface in positions where a positive growth of enamel surface had occurred. It was stated that this might be expected if the number of prisms on the outer surface equals the number on the inner surface, and *if* the density on the inner surface is fairly constant. The present results demonstrate that the total variation of prism density on the inner surface is probably no less than the variation on the outer.

For instance, the density in position 13 was significantly lower than the density in position 15 on the inner surface of both C_1 and C_4, see Table VI, whereas on the outer surface of the same specimens the density in reg. 13 was significantly *higher* than the density in reg. 15 (cf. part IV). Equivalent relations concerning the inner surface in positions 13 and 15 were also found to hold true for a third human canine, see Table VII.

On C_1 and C_4 the prism density at the amelodentinal junction in position 13 was the lowest of the 4 positions.

It is tempting to suggest that to a certain degree the prism density on the inner surface may be inversely proportional to the radius of enamel curvature and proportional to the enamel thickness. This would mean that the prism density on the inner surface in a given location has been influenced by the curvature of the dentinoenamel junction and by the future thickness of the enamel. The total variation on the inner surface would then act to reduce the variation on the outer surface. This would be in accordance with the results presented by *Pickerill,* (1913), who had found the smallest prism diameters on the inner surface in the cuspal region.

If the mean central distance symbolized by $\langle D \rangle$ is considered identical with the conception mean prism diameter, the smallest prism diameters calculated by the present author were found in a single group consisting of four prisms in the last ground surface of the depth series in position 15 on C_1. The $\langle D \rangle$-value for these prisms equalled $3.73\,\mu$, corresponding to a density of 81,973 prisms per mm^2. These 4 prisms represented an exception. The mean diameter of the total region was $4.33\,\mu$ corresponding to 60.655 prisms/mm^2.

Pickerill (1913) stated that he had measured diameters on the inner surface and found the average to be $3.1\,\mu$. Near the cusp he had found an average diameter of $2.5\,\mu$.

Yosida (1938) found an average diameter of $3.9\,\mu$ near the cingulum and $3.0\,\mu$ in the incisal region on the inner surface.

Thus the results of Pickerill and Yosida differ from those of the present author concerning the actual size of the prism diameters on the inner enamel surface.

The difference is, however, probably one of definition, since the former authors may not have included the interprismatic substance in their measurements.

Since the present investigation which was based on measurements in defined regions, indicated a great regional as well as a total surface variation of prism diameters, it seems impracticable to compare prism diameters of unspecified locations given by other authors with those presented in this paper.

CONCLUSIONS

In places where there has been an actual local growth of enamel surface during amelogenesis, the prism size on the outer surface is greater than on the inner surface of the enamel mantle of human maxillary permanent canines.

In such places there is also a compression of the prism pattern along the longitudinal axis of the tooth on the outer enamel surface, whereas such a deformation is smaller or absent on the inner surface. Hypothetically these conclusions are valid for all types of human permanent teeth.

In the enamel mantle of human maxillary permanent canines the variation of prism size within regions of equal areas is greater near the amelodentinal junction than on the outer surface. The total variation of prism density on the complete inner surface is probably as great as on the complete outer surface.

Hypothetically these conclusions are valid for all types of human permanent teeth.

SUMMARY

From definite regions on the outer enamel surface of 3 human maxillary permanent canines and one maxillary permanent canine from a dog, were prepared series of ground surfaces planoparallel to and towards the amelodentinal junction.

Within each surface of a series a region of a given area was photographed. All photographed regions within a series were equally orientated in relation to a straight line towards the dentine following the main prism course.

Within the photographed regions the distances between the apparent centers of adjacent prisms were measured. With certain reservations the central distances may be defined as prism diameters including the interprismatic substance.

From these measurements were calculated the mean central distance, the number of prisms per mm^2 and the mean compression ratio ⟨K⟩ which described the vertical deformation of the prismatic pattern.

On all four teeth, the prism density on the outer surface was generally significantly lower than on the inner surface in places where there had been an actual local growth of the enamel surface during amelogenesis. On one of the human canines this difference was demonstrated as a gradual increase of prism density towards the dentine in 3 such series.

No difference was found between the prism densities of the inner and outer enamel surfaces in the flat portion of the palatinal surface of the human canines.

Generally, there seemed to be no vertical compression of the prismatic pattern on the inner surface of human enamel, whereas there was a marked vertical compression on the outer surface in places where there had been a positive growth of surface during the amelogenesis.

No such compression was demonstrable on the outer surface of the dog's canine.

The results indicated a systematic difference between prism densities in given regions on the inner enamel surface of the three human teeth.

The author suggested that in human permanent enamel the centrifugal growth of prism diameters as well as the vertical compression is caused by the centrifugal growth of enamel surface during amelogenesis.

By tables and diagrams the variation of prism density and compression of pattern was demonstrated.

RÉSUMÉ

LA DENSITÉ DES PRISMES ET LEUR DISPOSITION À LA SURFACE INTERNE ET À LA SURFACE EXTERNE DU REVÊTEMENT D'ÉMAIL DES CANINES

Des séries de surfaces meulées parallèlement au plan de la jonction émail-dentine en allant vers cette jonction ont été préparées sur des régions déterminées de la surface extérieure de l'émail de 3 canines supérieures permanentes humaines et d'une canine supérieure permanente de chien.

Dans chaque surface d'une série, une région de superficie déterminée a été photographiée. Toutes les régions photographiées dans une série ont été orientées de la même manière par rapport à une ligne droite dirigée vers la dentine et qui suivait la direction générale des prismes.

Dans les régions photographiées, les distances entre les centres apparents des prismes adjacents on été mesurées. À quelques réserves près, les distances centrales peuvent être définies comme étant les diamètres des prismes, y compris la substance interprismatique.

Sur la base de ces mesures, on a calculé la distance centrale moyenne, le nombre de prismes par mm^2 et le taux moyen de compression (K) qui décrit la distorsion en direction verticale de la disposition prismatique.

Pour ces quatre dents, la densité prismatique était dans l'ensemble significativement plus basse à la surface externe qu'à la surface interne aux endroits où il s'était produit une croissance locale certaine de la surface de l'émail pendant l'amélogénèse. Sur une des canines humaines, cette différence a été mise en évidence sous forme d'une augmentation progressive de la densité prismatique en allant vers la dentine dans 3 de ces séries.

Aucune différence n'a été trouvée entre la densité prismatique de la surface interne et celle de la surface externe dans la partie plane de la face palatine des canines humaines.

Dans l'ensemble, il ne semblait pas y avoir de compression verticale de la disposition prismatique à la surface interne de l'émail humain, alors qu'il

existait une compression verticale marquée à la surface externe aux endroits ou il y avait eu une croissance certaine de la surface pendant l'amélogénèse.

A la surface externe de la canine du chien, on n'a pas observé de compression de ce genre.

Il ressort des résultats de cette étude qu'il existait une différence systématique entre les densités prismatiques dans des régions déterminées à la surface interne de l'émail des trois dents humaines.

Selon l'auteur, l'augmentation du diamètre des prismes en direction centrifuge et la compression verticale pourraient être causées par la croissance de la surface de l'émail en direction centrifuge pendant l'amélogénèse.

Les variations de la densité des prismes et de la compression de leur disposition ont été présentées sous forme de tableaux et de digrammes.

ZUSAMMENFASSUNG

NUMERISCHE DICHTHEIT UND MUSTER DER PRISMEN AUF DER ÄUSSEREN UND INNEREN FLÄCHE DES SCHMELZMANTELS VON ECKZÄHNEN

In bestimmten Gebieten der Oberfläche eines bleibenden Eckzahnes eines Hundes und drei mennschlichen bleibenden Eckzähne wurden Serien von Anschliffen gegen die Schmelz-Dentingrenze präpariert. Die Anschliffe waren planparallel zu der Grenzfläche zwischen Schmeltz und Dentin.

Innerhalb jeder angeschliffenen Schmelzfläche einer Serie wurde eine Region von bestimmter Grösse photographiert. Alle die photographierten Regionen einer Serie waren gleichmässig zu einer geraden Linie gegen die Grenzfläche zwischen Schmelz und Dentin orientiert. Diese gerade Linie folgte der Hauptrichtung der Prismenbündel.

Innerhalb der photographierten Regionen wurden die Zentralabstände zwischen benachbarten Prismen gemessen. Diese Zentralabstände möchten auch als Durchmesser der Prismen einschliesslich der interprismatischen Substanz definiert werden.

Von den erzielten Massen wurden der mittlere Zentralabstand, die Zahl der Prismen per mm^2 und die mittlere Kompression, $\langle K \rangle$, die die vertikale Deformation des Prismenmusters beschrieb, berechnet.

Auf allen vier Zähnen war die Dichtheit der Prismen auf der Schmelzoberfläche geringer als dicht bei der Schmelz-Dentingrenze, in Regionen wo es ein wirkliches Wachstum der Schmelzoberfläche während der Amelogenese gewesen war. Auf einem der mennschlichen Eckzähne wurde dieser Unterschied als ein allmähliches Wachstum der Prismendichtheit durch drei verschiedene Serien gegen die Dentingrenze demonstriert.

Kein Unterschied zwischen den Prismendichtheiten auf der inneren und äusseren Fläche des Schmelzmantels wurde im flachen palatinalen Gebiet der mennschlichen Eckzähne gefunden.

Nahe der Schmelz-Dentingrenze wurde keine vertikale Kompression der Prismen gefunden, weil eine markierte Kompression des Prismenmusters auf der äusseren Fläche des Mantels gefunden wurde, in Gebieten wo ein positives Wachstum des Schmelzes während der Amelogenese stattgefunden war. Keine Kompression des Prismenmusters wurde auf der äusseren Fläche des Schmelzmantels des Hundeeckzahnes gefunden.

Die Ergebnisse schienen einen systematische Unterschied zwischen Prismendichtheiten in gewissen Gebieten an der inneren Fläche des Schmelzmantels der drei mennschlichen Eckzähne zu zeigen.

Der Verfasser stellte die Hypothese auf, dass im Schmelz der bleibenden mennschlichen Zähne das centrifugale Wachstum des Schmelzmantels während der Amelogenese, ein zentrifugales Wachstum der Prismendurchmesser, so wie eine vertikale Kompression des Prismenmusters, verursacht.

Mit Hilfe der Tabellen und Diagrammen wurden die Variationen der Prismendichtheit und der vertikalen Kompression gezeigt.

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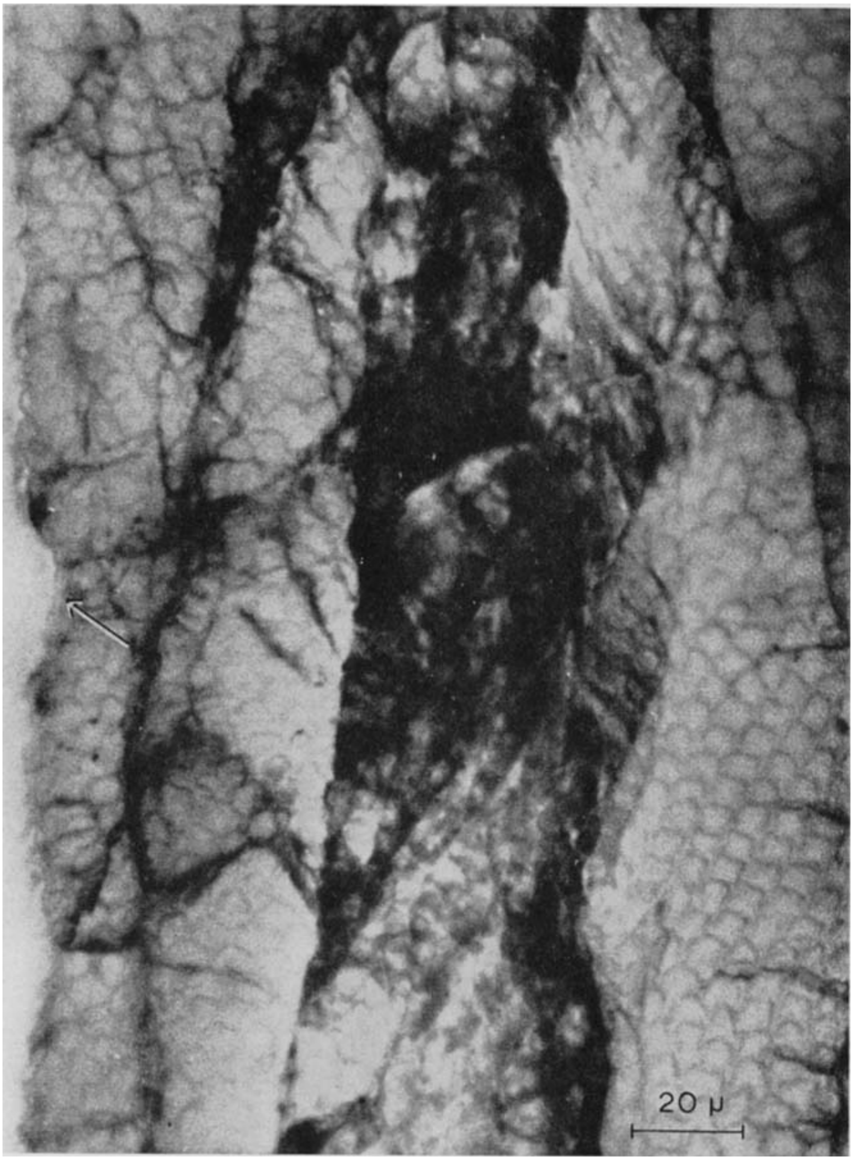


Fig. 7. The outer enamel surface of C_1 in position 2.

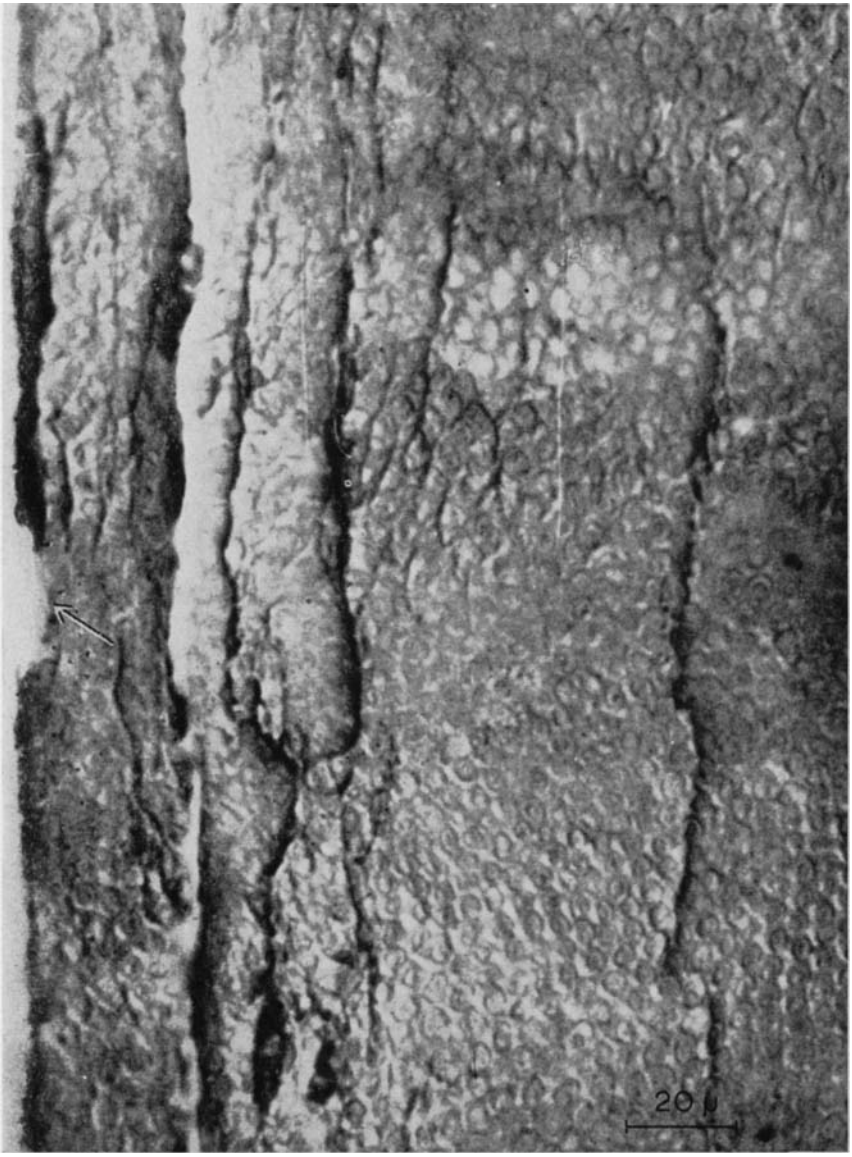


Fig. 8. The inner enamel surface of C_1 in position 2.

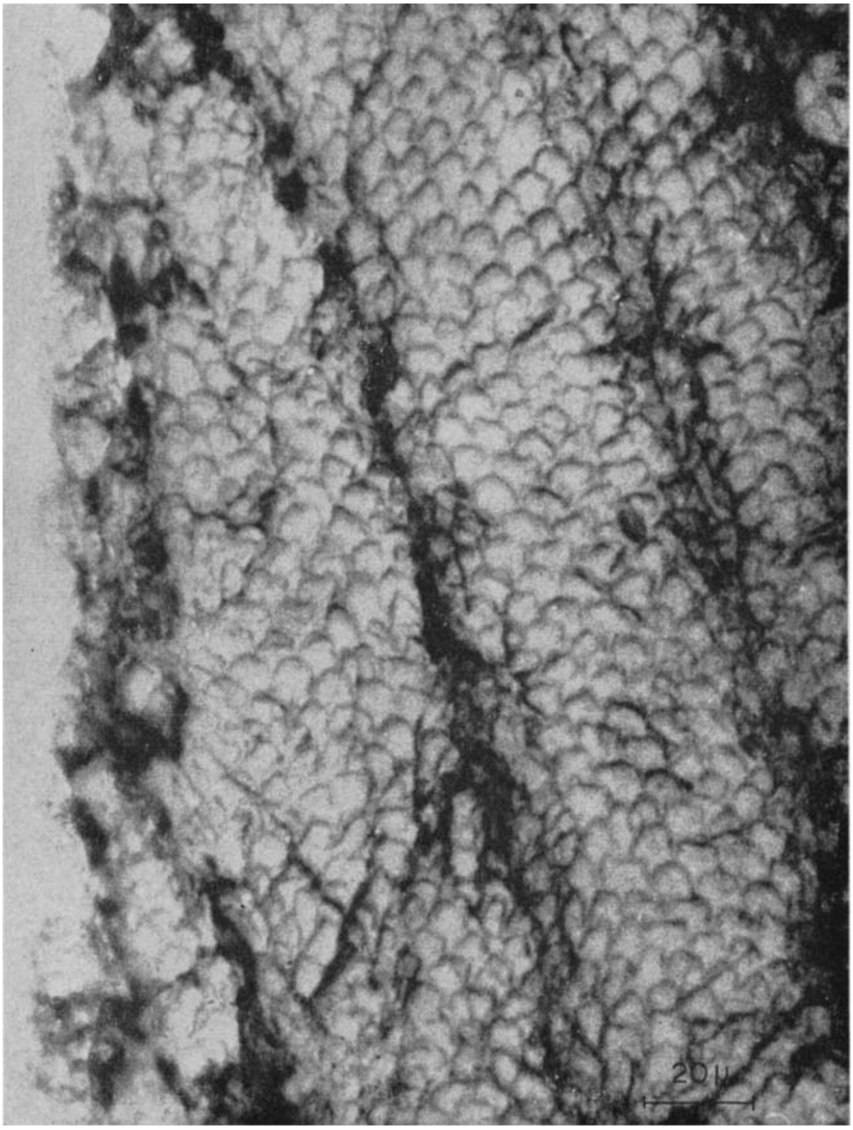


Fig. 9. The outer enamel surface of C_1 in position 7.

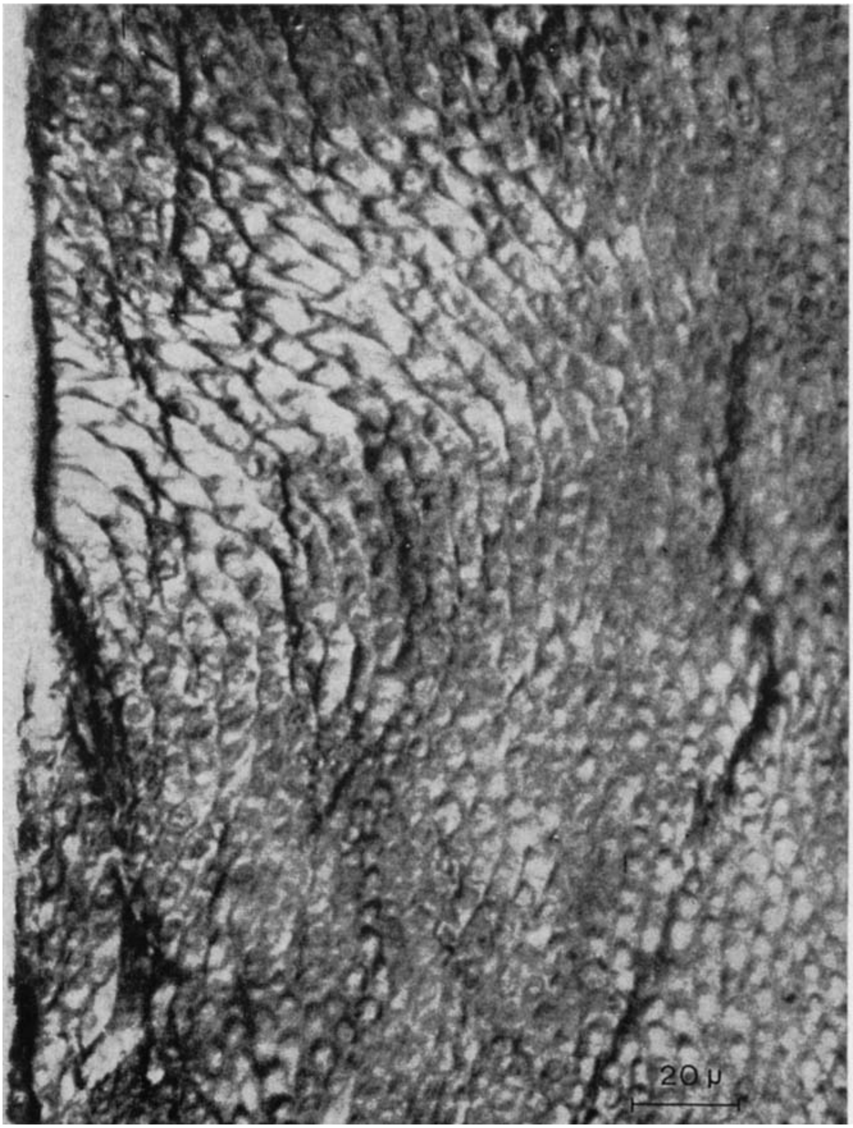


Fig. 10. The inner enamel surface of C_1 in position 7.

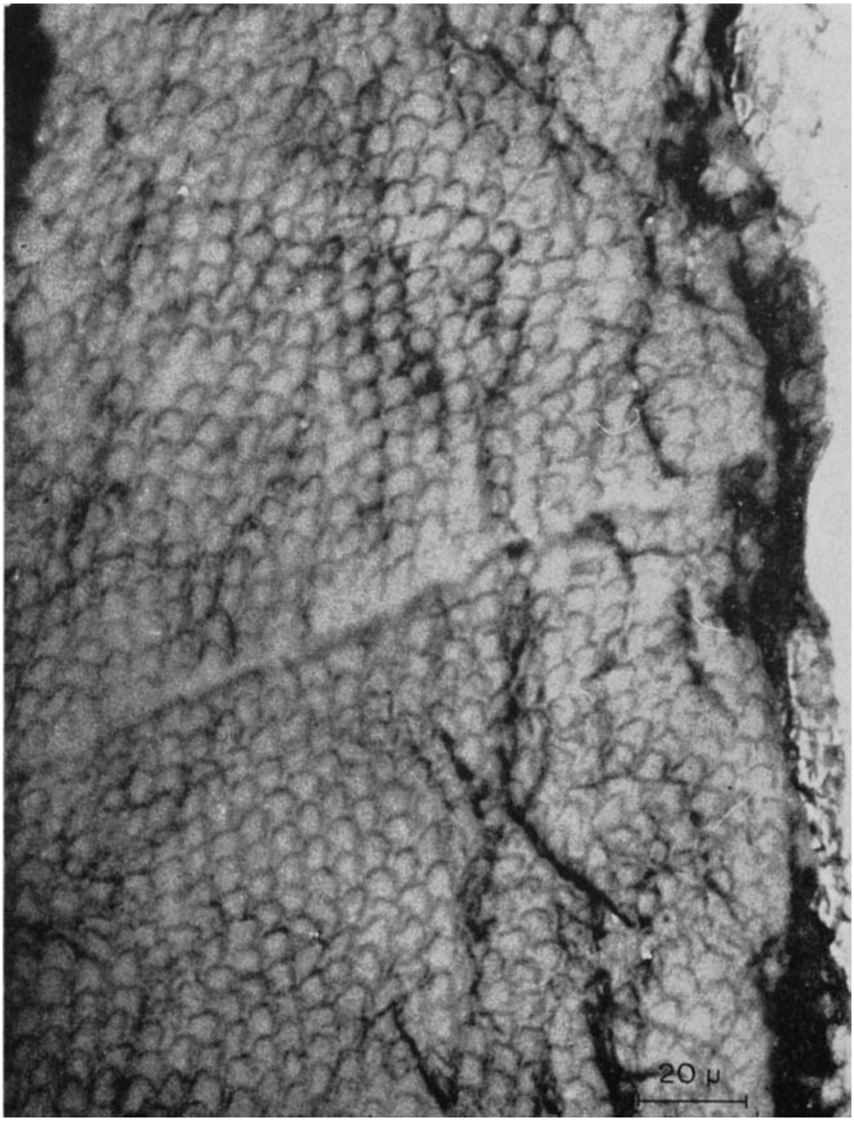


Fig. 11. The outer enamel surface of C_1 in position 13.

Fig. 12. The inner enamel surface of C_1 in position 13.

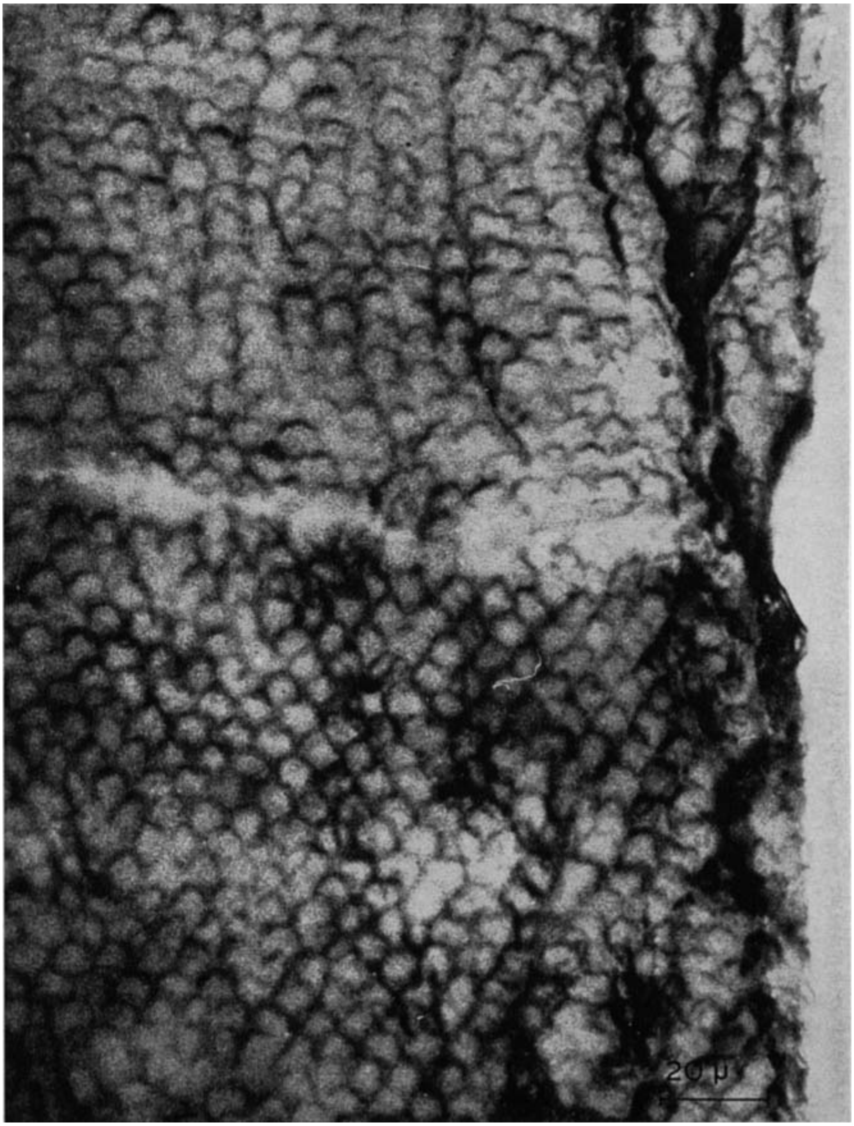


Fig. 13. The outer enamel surface of C_I in position 15.

Fig. 14. The inner enamel surface of C_1 in position 15.

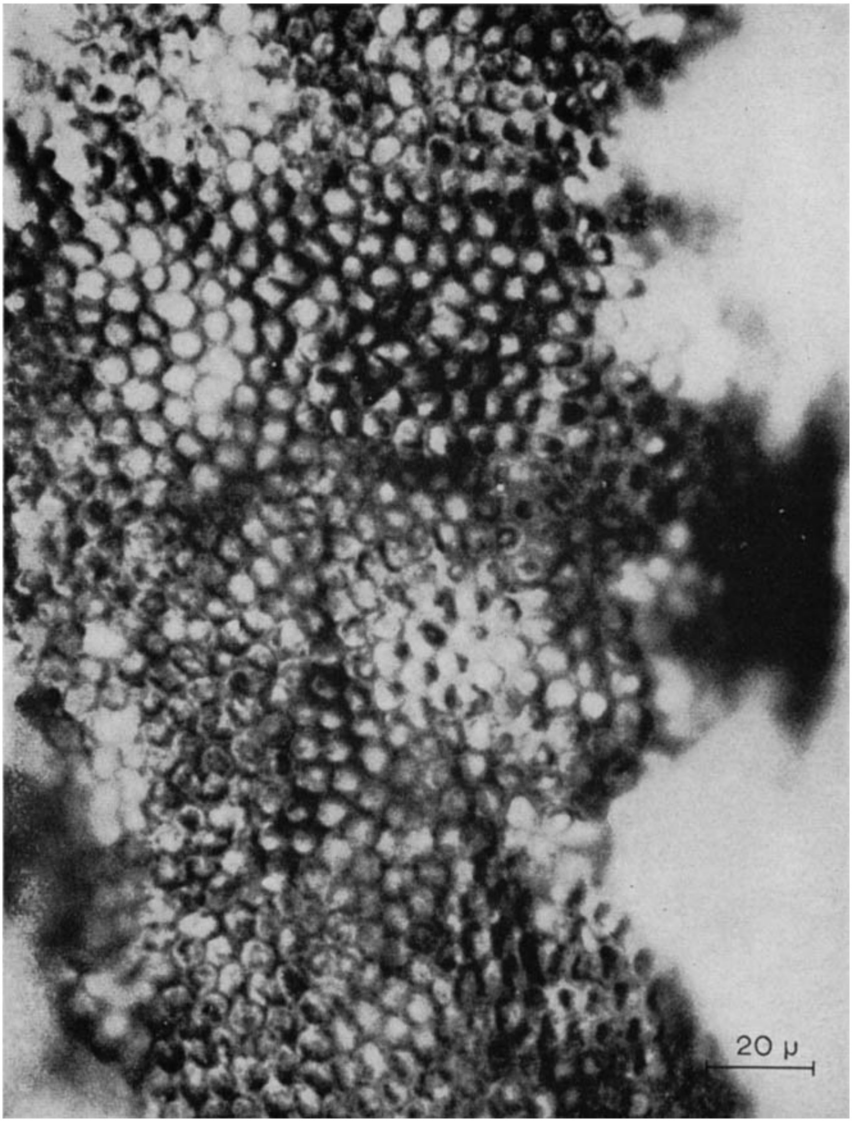


Fig. 15. The outer enamel surface of C_c in position 2.

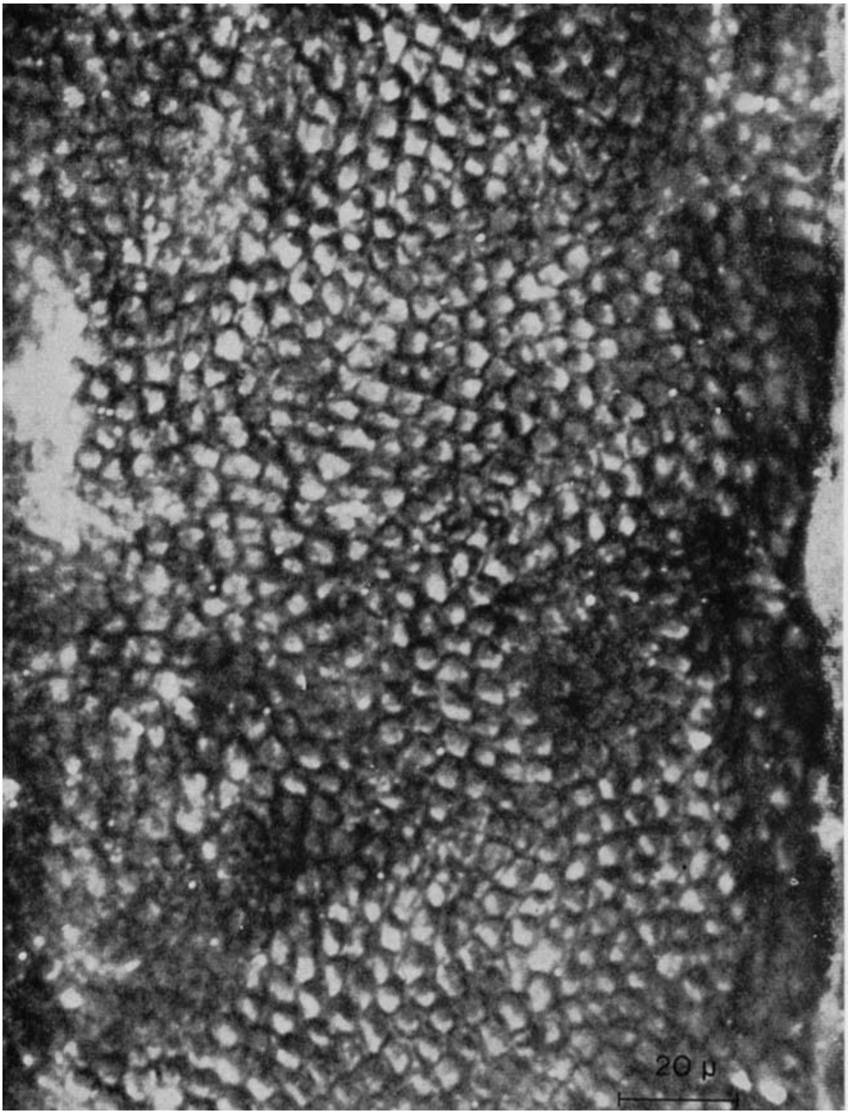


Fig. 16. The inner enamel surface of C_c in position 2.

Fig. 17. The outer enamel surface of C_C in position 13.

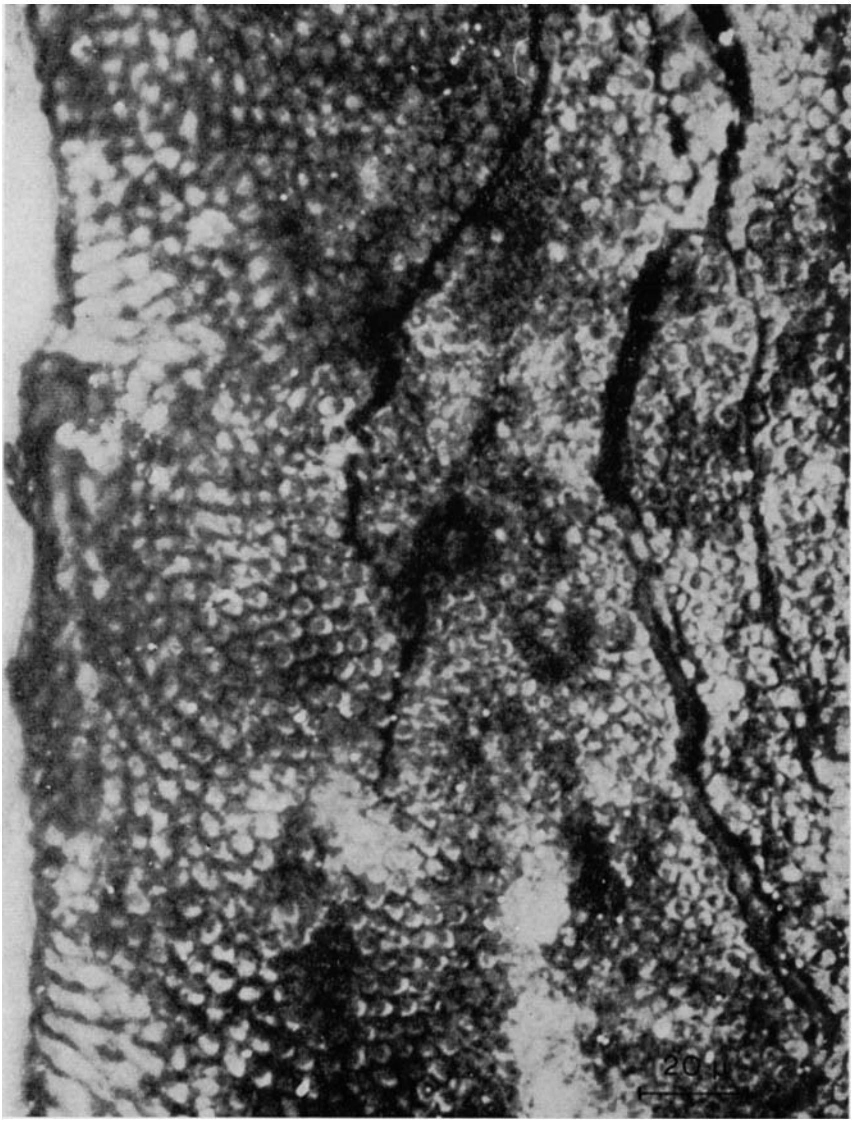
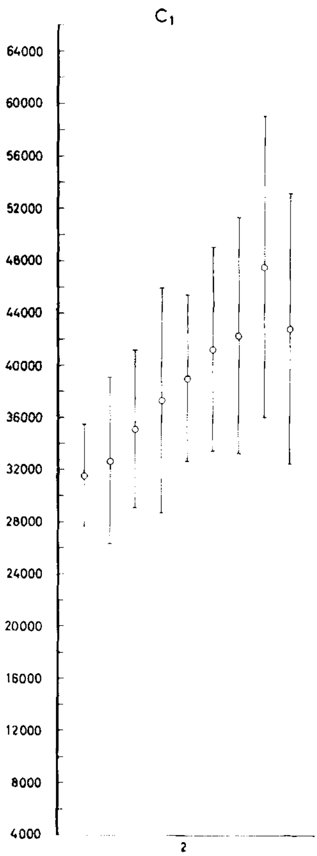


Fig. 18. The inner enamel surface of C_c in position 13.



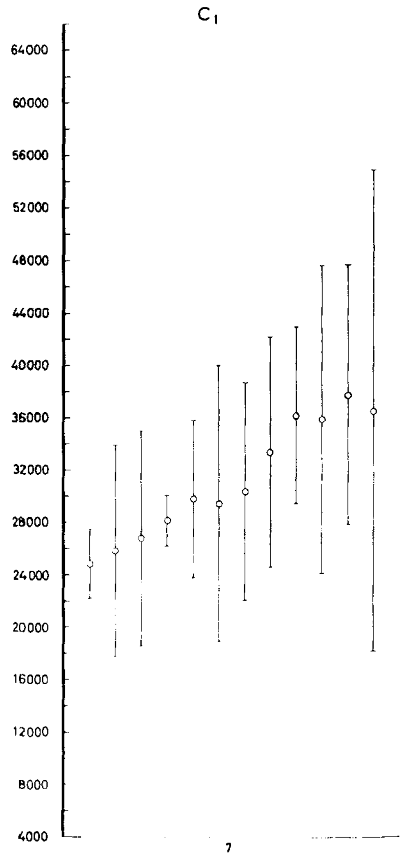
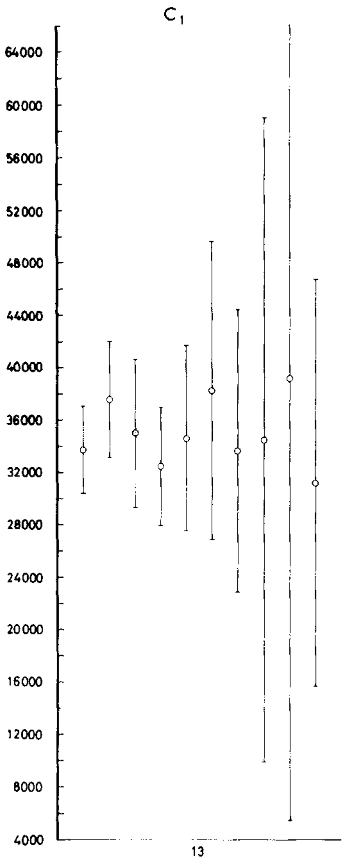


Fig. 19. Graphical representation of the prism density in a depth series on C_1. This series was situated in position 2. Each ground surface is represented by the encircled $\langle a_{gr} \rangle$-value and the double standard deviation added and subtracted. The outer enamel surface is represented by the first $\langle a_{gr} \rangle$-value at the left-hand side of the graph.

Fig. 20. Graphical representation of the prism density in a depth series on C_1. This series was situated in position 7. Each ground surface is represented by the encircled $\langle a_{gr} \rangle$-value and the double standard deviation added and subtracted. The outer enamel surface is represented by the first $\langle a_{gr} \rangle$-value at the left-hand side of the graph.



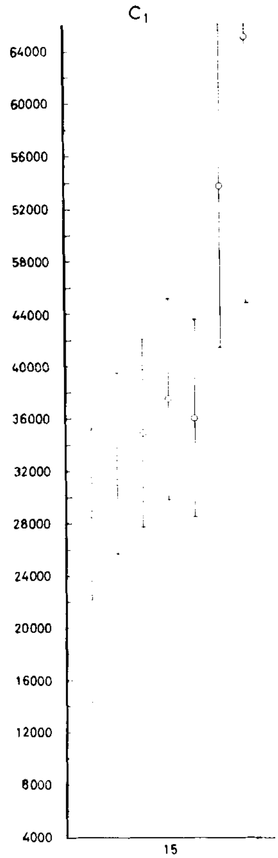
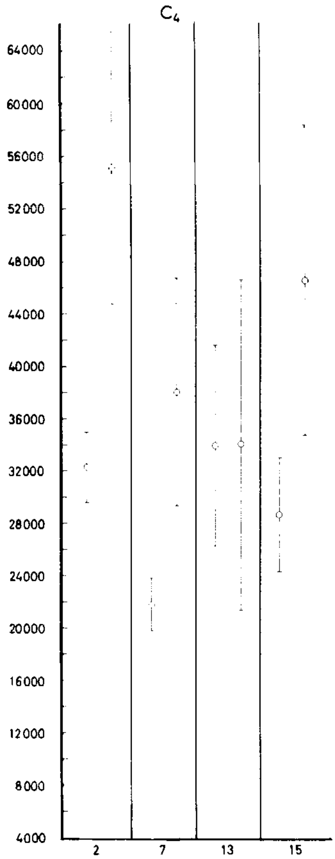


Fig. 21. Graphical representation of the prism density in a depth series on C_1. This series was situated in position 13. Each ground surface is represented by the encircled $\langle a_{gr} \rangle$-value and the double standard deviation added and subtracted. The outer enamel surface is represented by the first $\langle a_{gr} \rangle$-value at the left-hand side of the graph.

Fig. 22. Graphical representation of the prism density in a depth series on C_1. This series was situated in position 15. Each ground surface is represented by the encircled $\langle a_{gr} \rangle$-value and the double standard deviation added and subtracted. The outer enamel surface is represented by the first $\langle a_{gr} \rangle$-value at the left-hand side of the graph.



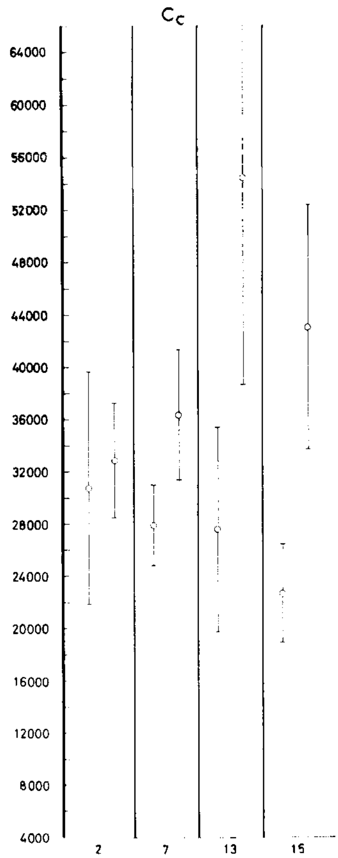


Fig. 23. Graphical representations of the prism densities on the outer and inner enamel surfaces in positions 2, 7, 13 and 15 on C_4. In each numbered position of the graph, the left-hand value represents the outer surface.

Fig. 24. Graphical representations of the prism densities on the outer and inner enamel surfaces in positions 2, 7, 13 and 15 on C_C. In each numbered position of the graph, the left-hand value represents the outer surface.

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