



The Research Department
CONDUCTED BY
**THE RESEARCH INSTITUTE OF
THE NATIONAL DENTAL ASSOCIATION
CLEVELAND, OHIO**

WESTON A. PRICE, M. S., D. D. S.,
President

SAMUEL E. POND, B. H., A. M., *Acting Research Director*



**PROGRESS OF THE YEAR IN THE INVESTIGATION OF
MOTTLED ENAMEL WITH SPECIAL REFERENCE TO
ITS ASSOCIATION WITH ARTESIAN WATER.**

By Frederick S. McKay, D.D.S., Colorado Springs, Colorado.

(Read before the National Dental Association at Its Twenty-First Annual Session, New York City, N. Y.,
October 23-26, 1917.)

WITH the publication of an article on Mottled Enamel, under joint authorship of the late G. V. Black and your grantee (Dental Cosmos, May to August, inclusive, 1916) the examination of afflicted territory was thought to have been completed, at least until some new district should be brought to light which might present some particular reasons which would make its examination of value to this investigation.

It will be recalled that the article as published in the Dental Cosmos, described several afflicted districts in Colorado, another in Texas, two in Virginia, several in Arizona—upon some of which certain Indian Tribes, notably the Pimas, presented an endemic percentage of practically one hundred,—and other

scattering districts in the Northwest, regarding which we have nothing more than suspicious evidence. The data presented in the article was not conclusive, but certain facts were established, which at least pointed the way to further investigation.

The serial publication of the article had scarcely been completed before I received a report from Dr. O. E. Martin, of Britton, South Dakota, that a well defined district, in which this lesion of the enamel was very prevalent, was located adjacent to, and including his locality; and with this, the astonishing information that the existence of the lesion was limited to individuals who had been raised on artesian water. The significance of this association with artesian water will be apparent when it is

recalled that, as shown in the Cosmos Article, the enamel lesion is found in direct relation with artesian water at Franklin and Courtland, in Virginia, and Amarillo in Texas, while in a less direct relation in Alamosa, Colorado.

It might also be proper to note here that at the Pictou and Chandler coal camps, in Colorado, a very pronounced affliction exists in association with water drawn from the shaft of the mine, which because of the depth from which it comes, might be considered as artesian water. That this assumption is justified, I hope to show later in this article, in tracing the geologic origin of the artesian water in the South Dakota basin.

An examination therefore, of this newly outlined district, was considered justified, and was undertaken early in October, 1916, the results of which I now aim to present in a somewhat detailed manner.

The physical characteristics of the endemic districts heretofore described, have varied thru an almost inconceivable variety. We have found these districts on the great plains, adjacent to the foothills of the Rocky Mountain Range; in the high metal-mining camps; at the entrance to some of the canyons piercing the mountain range; in desolate and barren coal-mining camps; in the timbered mountain defiles and passes; in the green meadows of mountain ranches; in the broad inland parks and valleys of mountainous country; on the coastal plain of the Atlantic Seaboard, not over forty miles from the ocean shore; on the plains of the Texas Panhandle; on the sun-baked desert in Arizona and Old Mexico; in the Italian littoral adjacent to the volcanic district near Naples,—and now, we are about to study a district situated in the broad and fertile plains of South Dakota.

EXAMINATION OF BRITTON, SOUTH DAKOTA AND VICINITY.

The occurrence of this lesion at Britton and Vicinity, had been noted by Dr.

O. E. Martin continuously during his practice there for the past ten or more years, and the one fact that had impressed him in trying to determine the cause, was that the lesion made its appearance subsequent to the time when the community began the use of artesian water as the principal source of its domestic supply, after 1898; and he noted further that those native individuals who had passed thru the period of enamel growth prior to the introduction of artesian water had normal enamel. That this fact is well established I hope to present proof by photographic evidence and carefully gathered histories later in this article.

The fact that the children born about the time at which the artesian water began to be used, and later, presented an affliction of mottled enamel of practically 100%, was borne out by an examination in the schools. In detail the findings were as follows:

NATIVES.		
Enamel	Water	Number
Normal	Well	4
Mottled	Artesian	78
NON-NATIVES.		
Enamel		Number
Normal		55
Mottled		0

The distinction here to be observed is that the *native* children represent, so far as this lesion is concerned, the influence of, or at least association with, artesian water, except the four found with normal enamel, who had been raised on well water.

On the other hand, the *non-natives* represent an association with water from other sources, particularly during the period of enamel formation.

Reduced to a concise statement, the children who had been raised on *artesian* water had *mottled* enamel, while those who had been raised on *other* water had *normal* enamel.

One of the facts that was amply demonstrated in the article published in 1916, was that enamel that was suffi-

ciently complete in its development, retained its normality, or was not affected by the peculiar influence acting in an afflicted locality if the individual subsequently became a resident of such locality; and the additional fact that any enamel in process of development at the time residence was established in an afflicted district, would at once become affected by the damaging influence, and would upon eruption show so sharp a line of demarcation, even upon individual teeth, or would show so marked a difference in appearance in the different groups of teeth, as pointed out by Dr. Black, as would enable the experienced observer to say closely at what age the individual came into the afflicted locality.

Let us see now, if this be the case with reference to the district we are studying, by examining some individual histories.

ciently advanced before commencing the use of artesian water, that enamel formation was complete beyond possibility of damage, except possibly the third molars in some cases. This might be the case in numbers 8 and 17, while on the other hand, cases like these two have been found in other endemic districts, to show damage to the second group of teeth.

We should not fail to consider, in tabulating these conditions, the difference in the amount of enamel development in the two groups of teeth, varying in different individuals of the same age, without departing from what we might term a correct average. Such a variation might possibly account for the case of Harry N—in whom the first group was normal and the second group mottled, the use of artesian water having begun at the age of three years. In the average instance we might expect the first group

Name	Enamel	Use of artesian water commenced at age of
1 Leslie C.	(First group normal (Second " mottled	at 6 years
2 Harry N.	(First group normal (Second " mottled	at 3 "
3. Ernest B.	Normal	No artesian water used
4 Emerson H.	"	at 14 years
5 E— P—	"	at 13 "
6 Sarah W.	"	at 6 " not much used
7 — R.	"	at 11 "
8 Mabel J.	"	at 6 "
9 — Roehe	"	No artesian water used
10 Ella P.	"	at 15 years
11 Marion J.	(First group normal (Second " mottled	at 3½ "
12 Grace J.	(First group normal (Second " mottled	at 5 "
13 Melvin S.	(First group normal (Second " mottled	at 6 "
14 Bertha P.	Normal	at 11 "
15 Elsie C.	(First group normal (Second " mottled	at 5 "
16 Gracene J.	(First group normal (Second " mottled	at 6 "
17 Elsie B.	Normal	at 8 "

Note: First group of teeth includes incisors, cuspids and first molars.

Second group of teeth includes bicuspid and second molars.

Attention is called to the similarity between numbers 3, 4, 5, 6, 7, 8, 9, 10, 14 and 17, in that little or no artesian water was used, or the age was suffi-

cient to show the lesion to some extent under such conditions.

The Cosmos article pointed out the inhibitory influence that the removal of

a native from an afflicted district exerted upon the manifestation of this lesion, which is borne out in the case of Geo. H., who was born in Britton, moved to Canada at the age of two years, returning to Britton at the age of ten, and who presented normal enamel. If any damage had been done to the first group of teeth prior to his removal, at the age of two, it had evidently been repaired in the new environment, or at least future normal enamel development was assured and all enamel made safe, except possibly the third molars.

A somewhat similar case was that of a child who removed from Britton at the age of five years to another part of the State, supposed to be non-endemic, and returned to Britton at the age of ten,—showing the second group of teeth mottled. It is presumed that the difference in development of this group of teeth in these two individuals at the same age, with almost the same kind of migration, would account for the difference in results.

It has been shown during the progress of this investigation that the temporary teeth in all endemic localities, were invariably free from this lesion, but a curious exception appears to have been found at Britton. Wade H.— gave a history of bottle feeding after the age of six months, the food having been diluted or mixed with artesian water, and the temporary teeth showed a distinct mottled appearance. Whether the supposed cause and effect acted conjointly to produce this peculiar result, is a matter for conjecture.

Another interesting exception was that of a child who, being native to Britton, had avoided the use of the city artesian water and had been restricted to the use of a water that has been regularly marketed in the locality, from a spring adjacent to the town, and who had normal enamel. The city artesian well was sunk in the year 1898, primarily for fire protection, and few mains were laid. The water was not

pleasant to taste and was not used generally for domestic purposes at first. A few cases of typhoid fever supposedly caused by the use of shallow wells, helped to bring the artesian water more into general use, and as the town became able to afford it, the mains were extended from year to year and piped into the houses, and the shallow wells abandoned for the artesian water, which was considered to be germ free. Before sinking the artesian well the people depended entirely on shallow wells, dug or bored from 20 to 50 feet in depth. The pressure from the artesian well was at first 120 pounds per square inch, but has since dropped to about 60, due no doubt to the continued use and the various other tapings of the underground reservoir in the vicinity.

In presenting photographic evidence of the existence of this lesion in this district, I will call attention to the fact that no matter in what part of the country it has been found to exist, it always takes on the same characteristics of appearance, and is distributed upon the same areas of the teeth in a typical fashion.

Figures 1, 2 and 3 require little comment, except to say that they are all typical of conditions found in that city.

Figure 4 illustrates a girl of about 16, who was born at Britton after the introduction of artesian water, and had used this water continuously and exclusively. The teeth show in general, the characteristic whiteness, with pronounced staining of the labial surfaces of the upper incisors, the stain being distributed in characteristic fashion.

No other teeth nor surfaces are stained, which is also characteristic. Pits are seen on these same surfaces, and faintly upon the cusps of the bicuspid, upper and lower, which is also characteristic.

Figure 5, an adult sister of the previous illustration, was also born at Britton, prior, however, to the use of artesian water, and was raised upon water from a shallow, or "dug" well.

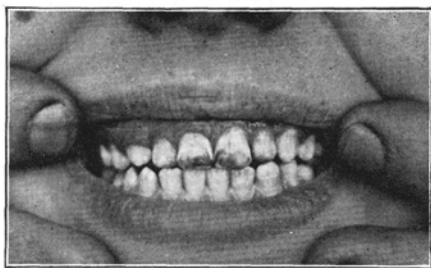


Figure 1.

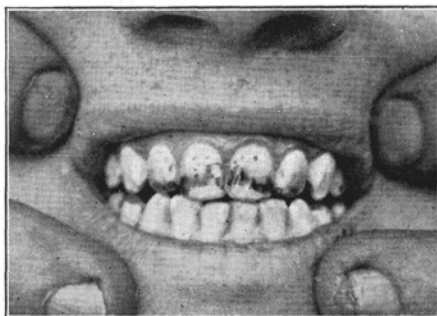


Figure 4.

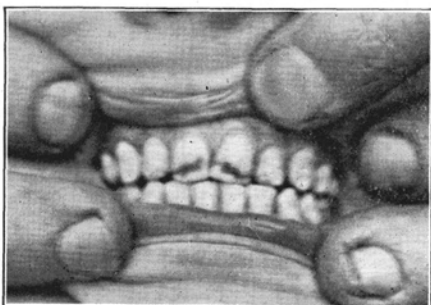


Figure 2.

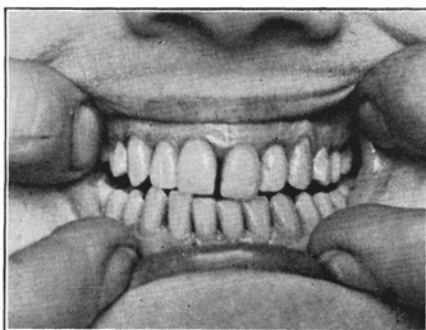


Figure 5.

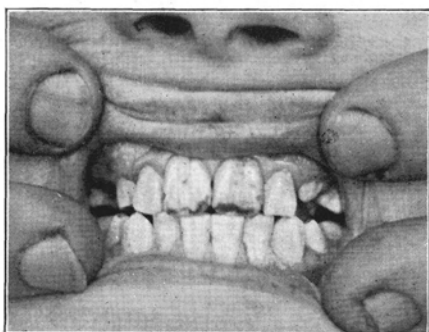


Figure 3.

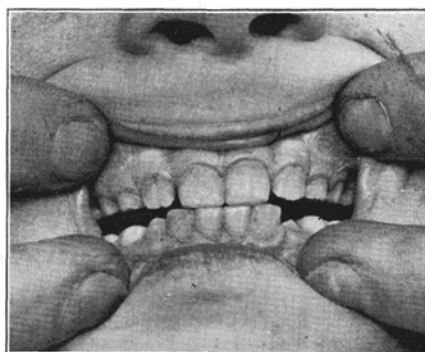


Figure 6.

The enamel of all her teeth was grown in exclusive association with the use of shallow well water, and its absolute normality, of freedom from this lesion, is well illustrated.

Figure 6. This illustration shows a child about eleven, L— Hamilton, whose enamel on the permanent incisors is perfectly normal. This child is one of five, all born on the homestead where now living, and all having normal enamel. It seems that because of their dislike for the taste of the artesian water, it was not piped into the house, the family preferring to continue the use of the 52 foot well in the yard, which had been in constant use for 28 years when our examination was made.

Another interesting bit of evidence relating to the influence of this same well is furnished by the A— family, who were also among the early settlers and lived on the property adjoining the Hamilton place. Two children were raised there with constant use of the Hamilton well, and have grown normal enamel.

EXAMINATION OF KIDDER, SOUTH DAKOTA.

This small community is adjacent to Britton, a few miles to the north and east, and its topography is very similar to that of Britton. An examination of the school children revealed the following:

Native children presenting mottled enamel, 17.

Native children presenting normal enamel, 0.

Non-Native children presenting mottled enamel, 0.

Non-Native children presenting normal enamel, 6.

Twenty-three of the twenty-nine children examined are here accounted for, the remaining six being unclassified because of lack of permanent teeth or doubtful histories.

Like Britton, the water used for several years, is practically all artesian,

both in the town and on the adjacent farms, about as many of the children seen coming from the farms as living in the town.

Fig. 7 shows a case found at Kidder, and is typical in many ways, particularly in the symmetrical location of the stain upon the upper central incisors. All the enamel is characteristically mottled.

The next five illustrations are introduced as being of intense interest, and as contributing the most conclusive evidence bearing upon the etiologic influence of the water, that it has so far been my privilege to present during this investigation.

Among the cases found in the school at Kidder were two brothers, Richard and Elbert Hardina (twins), who are illustrated in Figs. 8 and 9 respectively.

My readers will readily agree that any influence that operates to produce such havoc and destruction of the dental organs in childhood, as has been produced in Elbert's case (Fig. 9) is worthy the resources of our Research Institute to discover.

I need not describe this case further than the illustration shows, except to say that the rest of the teeth, not shown in the picture, are as badly damaged. What prospect has this boy of ever enjoying the normal use of a dental apparatus or of escaping the total destruction of the dental organs long before middle life?

Richard's condition (Fig 8) is less marked than that of his brother, but the effects of a destructive influence of some sort is only too plainly apparent.

A moment should be taken right here to contrast this phase of the lesion in which the teeth present every appearance of having been subjected to a corrosive action, with what might be called the "smooth" type, such as is illustrated in Fig. 7 which was grown in the same community, and presumably produced by the same influence.

By far the most typical manifestation

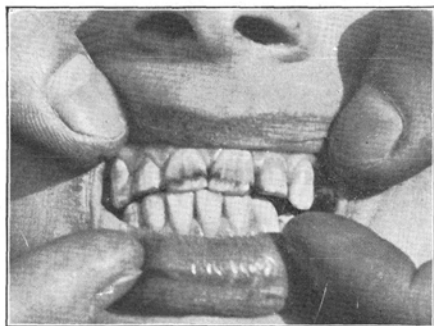


Figure 7.

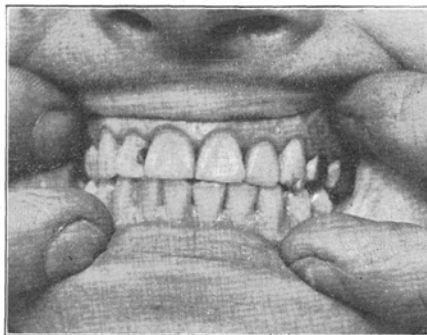


Figure 10.

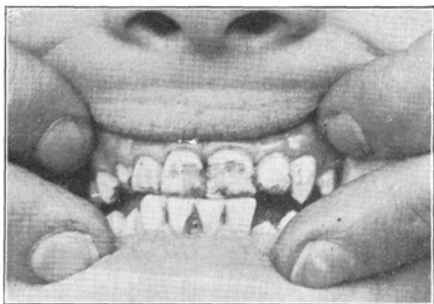


Figure 8.

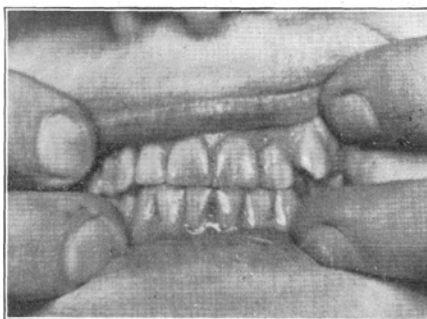


Figure 11.

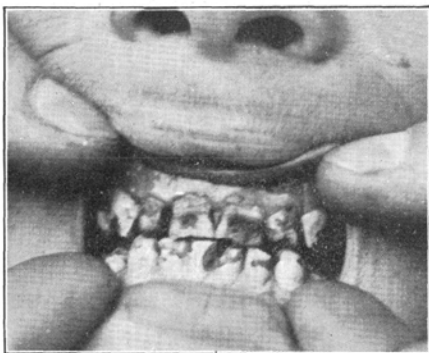


Figure 9.

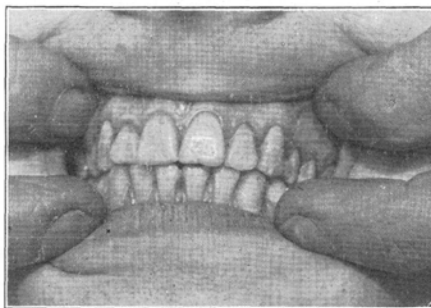


Figure 12.

is the "smooth" type, which has been abundantly illustrated in previous articles—(Dental Cosmos May, 1916.) (Journal N. D. A. March, 1917) and in which the enamel presents the same glazed and unbroken surface as does normal enamel.

These two boys were immediately marked for further study, and later that day the home on the farm at the outskirts of the town, was visited, and the following history obtained.

EXAMINATION OF THE HARDINA FAMILY

The artesian well was sunk in 1906 and extends to the usual depth (about 1300 feet) for that locality. Prior to this time the domestic supply was obtained from a shallow well dug in the yard, the location of which is still visible, altho it has been filled in for several years.

Six children were born and lived to maturity on this farm, and presented evidence as follows:

Frances, the oldest child, was born in 1892, consequently was 14 years old when the artesian well was sunk. Her enamel is normal, as shown in Fig. 10, except that the third molars are pronouncedly and typically mottled. The explanation of this has been carefully given in my previous articles, so will not be repeated here.

The second child, Mildred was born in 1894, so was 12 years old when the artesian well was sunk. Her enamel is normal, as shown in Fig. 11, except the third molars, which were typically mottled.

The third child, Mrs. F., was born in 1895, so was 11 years old when the artesian well was sunk. Her enamel is normal as shown in Fig. 12 excepting again, like the two older sisters, the third molars, which were typically mottled.

These third molars were covered with such defective enamel that they were practically destroyed by decay before being extracted by Dr. Martin. (Figure 13.)

The broken edge of enamel in No. 2 shows its unorganized character, and No. 4 gives an idea of the "dead white" color of the tooth.

The fourth child, another daughter, Anna, whom I did not examine, was born in 1901, hence was five years old when the artesian well was sunk. Dr. Martin states that the first group of teeth is normal, but that the bicusps and second molars are typically mottled, which condition of things is exactly what would be expected in similar circumstances from previous experience in the various endemic fields.

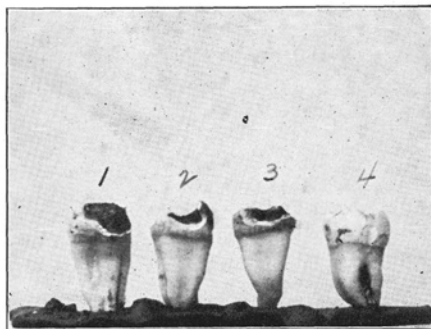


Figure 13.

The two twin boys, (Figures 8 and 9) were born in 1906, the same year the artesian well was sunk, hence all their enamel was grown in exclusive association with the artesian water, and the results are only too evident in the illustrations.

If such evidence as this, so clear and straightforward, that the use of artesian water in that territory is in some way accountable for the disturbance in the structure of the enamel, cannot be considered as conclusive, then, pray, what sort of evidence shall we collect?

EXAMINATION OF HAVANA, NORTH DAKOTA.

The State line dividing South from North Dakota, is crossed just before coming into the town of Havana, but

the general characteristics of the country remain the same, except possibly that it is a little more rolling. Havana is, like the places previously examined, an agricultural district.

An examination of 21 pupils in 7th and 8th grades in the school, gave the following data. Eighteen of them were native to Havana; and of these fifteen had normal enamel, and had been raised on shallow well water. The remaining three had mottled enamel and had been raised on artesian water, two of these being in the same family (Mapes) living on a farm about three miles out. The significant fact here is that this community has avoided the use of artesian water, the residents depending upon the water from shallow or dug wells, and coupled with this circumstance, from the standpoint of this investigation, is the fact that the children have escaped this lesion of the enamel. Three children of the 21 examined were not native to Havana, and had normal enamel.

The conditions found in this community just described, are certainly in utter contrast with those found in Kidder and Britton, and so far as the examiners were able to determine, the only difference was in the character of the water supply, total immunity from the lesion existing where artesian water was not used, and universal existence of the lesion where artesian water was used.

EXAMINATION OF LANGFORD, SOUTH DAKOTA.

In considering the extent and outlines of the artesian basin over which the foregoing communities are located, I will, later in this article, show that its general direction extends north and south, and the examinations were continued thru those towns to the south which were known to be afflicted, following the line of the branch railroad which joined the main line of the Chicago, Milwaukee & St. Paul at Andover, South Dakota.

Twenty-four native children were examined in the school of whom twelve showed *normal* enamel, having been raised on *well* water, and twelve showed *mottled* enamel, having been raised on *artesian* water. Two non-natives were seen, whose enamel was normal. No non-natives were seen who showed the lesion. Seventh and eighth grades only were examined, in order that only those children who were free from temporary teeth would be seen.

EXAMINATION OF PIERPONT, SOUTH DAKOTA.

In the seventh and eighth grades and High School, were found thirty-nine children, of whom twenty showed *normal* enamel, having been raised on *well* water, and nineteen showed *mottled* enamel, having been raised on artesian water. Four non-natives were seen who had normal enamel. None of the non-natives showed the lesion.

EXAMINATION OF ANDOVER, SOUTH DAKOTA.

No tabulation was made of the examination of the children in the school, but a casual search revealed an abundance of evidence exactly in conformity with the previous examinations, namely, that this community had a high percentage of affliction among its natives, and that the occurrence of the lesion was absolutely associated with the artesian water, which had been in use in the town for many years.

EXAMINATION OF GROTON, SOUTH DAKOTA.

Various other communities, located in adjacent districts, not easily accessible, were brought to light during these examinations, as being possibly suspicious territory, as far as this lesion is concerned, but the examinations were continued by turning west at Andover, along the main line of the railroad.

The school at Groton showed the same association of artesian water with mot-

tled enamel, and immunity in association with well water. At the same time it was noted by the examiners that there was here beginning a slight change in the character of the data obtained, in that there was some element of confusion in the histories of the children as given. There had been more of a mixture of various waters at different periods of enamel growth, and the results upon the teeth did not follow with the same constancy as had been observed in the other afflicted towns.

To illustrate: many children who had had artesian water since early life, even since birth, would show only the second group of teeth (bicuspid and second molars) mottled, while the first group (incisors, cuspids and first molars) appeared normal. Apparently some item in the environment was at variance with the other typically endemic districts.

EXAMINATION OF ABERDEEN, SOUTH DAKOTA.

The examination was concluded at Aberdeen, which is the chief center of population in that part of the State. Being a City of, I should say, about thirty thousand people, there is necessarily met a vast diversity of environment, which introduces bewildering confusion into the collection of such data or facts as are of value in the investigation of a problem like this one.

This very circumstance seems to indicate the wisdom of devoting the major part of the study of the present year, to those smaller areas and isolated spots, in and upon which the secret of the problem lies hidden within a very circumscribed space. However, much valuable information was secured by observing conditions in this city.

An examination of a large group of children in the principal school, demonstrated that the endemic percentage in the present generation is high. A very confusing feature in conditions was the fact that in certain parts of the city

"neighborhood" artesian wells, say one to each city block, had been sunk to supply some of the inhabitants of the block. I learned there were from seventy to one hundred of these private "soft water" artesian wells thruout the city, of about 1100 feet depth. In general, however, the source of supply was from the municipal well or wells, as I understood there was, or had been, more than one.

Information received from city officials, was to the effect that the first wells were sunk about 1884, and delivered what was spoken of as "soft water." These wells went down about 900 feet, and evidently tapped a body of water of limited size, as they "played out" or were exhausted after a few years of use and municipal growth. Then, about ten years ago, deeper wells were sunk, going down to 1300 feet, bringing what is called a "hard" water.

In trying to understand the use of the terms "hard" and "soft" as applied to water, it is necessary to point out that these terms apply to the action upon soap, the "soft" water lathering freely, and the "hard" with difficulty. An artesian water may be either "hard" or "soft"—and so may water from a shallow well. It is the "hard" artesian water from the deeper flow that is in general use at the present time.

The fact is, that in a large group of children seen, those having mottled enamel invariably stated that they had used the city artesian water constantly since birth, or early childhood.

Thru the courtesy of Dr. Schweiger I had opportunity of making an interesting and significant observation of a lady, born in Aberdeen and raised on the water from the first artesian wells sunk, which I described as "soft." Her enamel is normal, while that of her children, raised upon the present water from deeper wells, described as "hard," have the typical mottled enamel. Certainly this instance, which I am sure could be duplicated many times, must be granted as indicating that some influence has

made its appearance in later years in this community which accounts for the existence of defective enamel in the present generation, which was absent in the previous generation. If not the

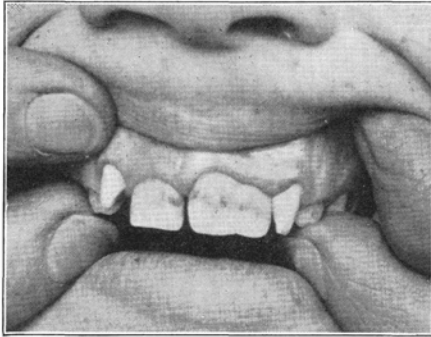


Figure 14.

change in the character of the water, what?

An examination was also made of a group of pupils at the State Normal School at Aberdeen, at which young adults from various parts of the State

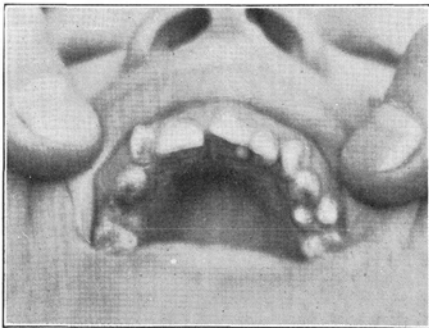


Figure 15.

were in attendance, but no other suspicious territory was brought to light.

Figures 14, 15 and 16 are introduced to illustrate a curious anomaly found in a boy in the Aberdeen School. Besides being mottled, the left Central and Lateral Incisors are fused, a pronounced cingulum being present, (Figure 15)

the roots being separate as shown in the X-ray. (Figure 16.) Another permanent lateral incisor is present on the same side and the temporary cuspid.

A STUDY OF ARTESIAN WATER IN GENERAL, WITH PARTICULAR REFERENCE TO THE BASIN UNDERLYING SOUTH DAKOTA.

The evidence presented by the examinations of these Districts in South Dakota must make it plain that there is a relation most definite and conclusive existing between the use of water drawn from these artesian wells during the

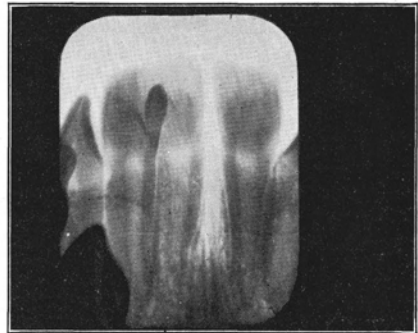


Figure 16.

period of enamel growth, and the existence of the enamel lesion. It certainly seems more than a coincidence. Since this is the case, then it would seem most important to investigate the extent of the artesian basin, determine the source of the water, and most important of all, determine its chemical ingredients. I find upon reference to the publications of the United States Geological Survey that a great deal has been published concerning this artesian district, as a result of the examinations made by the Geologists of the Survey, several years ago, long before any such properties as these waters seem, by this investigation to have been shown to exist, were thought of or considered possible.

In order that we may have a more

definite idea of what is meant by the term "Artesian" as applied to waters, I quote from Bulletin 44 issued by the Bureau of Economic Geology, University of Texas (Udden & Baker.)

"All underground water is derived from rainfall. It may be classified as non-artesian and artesian. The latter is water under hydrostatic pressure. Artesian water may flow when reached by the drill, or it may escape in springs, or it may be non-flowing, rising to a greater or less depth in the well. Water in the deeper wells is more thoroly filtered and usually more highly mineralized than the surface waters. The mineral matter is taken from the rocks by the water in its passage thru them. Generally speaking, the farther the water travels underground, the more highly mineralized it becomes. Thus it is that some underground waters are usable when they are taken from near the area where they are derived from rainfall, while farther away from the area, they are unfit for use."

In a "Preliminary Report on Artesian Waters of a Portion of the Dakotas" by N. H. Darton, extracted from the 17th Annual Report of the United States Geological Survey, 1895-6, I find much of interest bearing upon the origin of these waters.

In this report, the geological features of North and South Dakota are declared to be relatively simple, being uniform over very wide areas. This is in direct contrast to the geologic features of the Rocky Mountain district, where so many of the endemic areas are located, the strata here being, in places, literally turned up on end, making their comprehension difficult to the layman.

In gaining some idea of these water-bearing areas in the artesian district, it is necessary to consider the geology, at least briefly.

Various layers, consisting of gravel, sands and clays lie between the surface

and what is known as the Dakota sandstone, which has proven to be the great water-bearing layer. This sheet of Dakota sandstone underlies practically the entire State, but as it extends westward, it curves upward and comes to the surface with the edge turned upward, just at the border of the great Rocky Mountain Highland. This feature is diagrammatically shown in its westernmost extension only, on account of lack of space, in Figure 17.

Darton in this report, describes what the diagram shows, in these words: "From its outcrops in the Black Hills (and Rocky Mountains), it sinks deeply beneath the surface, and then gradually rises to the eastward. It finally abuts against the crystalline bed rock along the Eastern border of the State, at no great distance beneath the surface, where its waters are more or less free to escape, and the eastern limit of the basin is determined. The waters have a head which is relatively great to the westward, but gradually diminishes to nothing at the eastern border of the basin. There are wide areas in which this head is sufficient to give surface flows in artesian wells, but, on the other hand, there are many thousand square miles which are too elevated for artesian flows." He names as one of these "elevated" regions, the eastern Coteau in South Dakota, which is of some interest from the standpoint of the data collected in that district during our investigation.

Figure 18 shows the extent of the artesian basin and the area covered by our examination can be recognized by starting at Aberdeen and following east thru Groton and Andover, thence north thru Langford, Britton and just over the North Dakota line to Havana, which is not shown in the map.

The special point just here, however, is that the basin is seen to stop just east of Britton, at which point rises a series of low hills, referred to by Darton as the

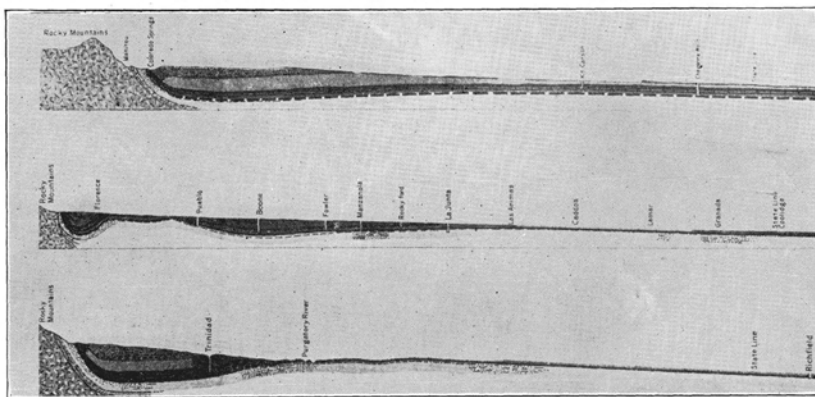


Figure 17.

Westernmost extension of Dakota Sandstone Sheet, showing its upturned outcrop adjacent to Rocky Mountain Range. Sandstone Layer is one of the dark layers near bottom.



Figure 18.

Map of Artesian Basin in South Dakota. (Darton—U. S. Geol. Survey.)

“Eastern Coteau,” but spoken of locally as the “Hill Country.”

Dr. Martin stated particularly that no cases of mottled enamel had been observed in, or coming from this “Hill Country,” and I recall having observed several persons who had come from there who had normal enamel. All gave a history of having used spring water, and no borings in that district had been successful in obtaining a flow of artesian water.

RELATION OF THE WATERS IN THE ARTESIAN BASIN OF SOUTH DAKOTA TO THE ROCKY MOUNTAIN REGION.

It would seem a far cry to try and connect or relate the water delivered from an artesian well in Eastern South Dakota with water originating on the Rocky Mountain Range, but evidence contained in several of the reports of the Geological Survey by Darton and others, seems not only to bring this into the realm of possibility, but to show conclusively that such a relation exists.

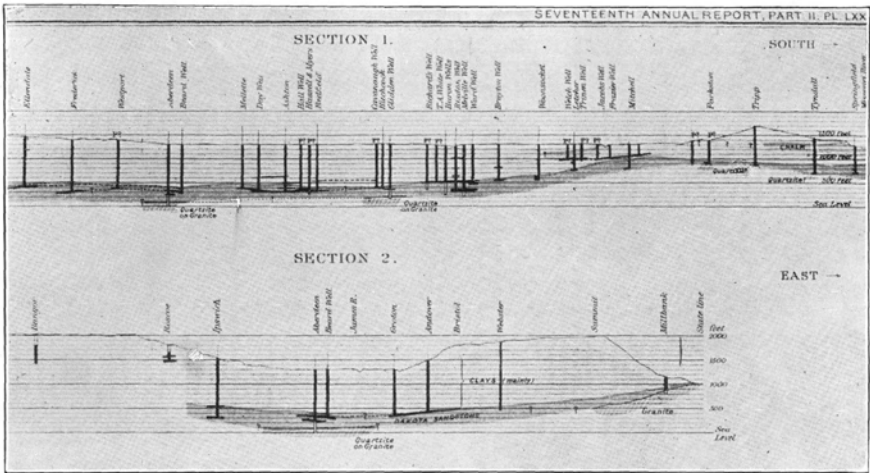


Figure 19.

Darton makes it clear either that the limit of the basin had been reached, or that the elevation of the land was so great that the depth necessary to reach the flow would be too great to be practical, the attenuated head of pressure which the water would have at that distance, being insufficient to bring it to the surface.

Fig 19 is a diagrammatic representation of different well-borings reaching down into the Dakota sandstone layer to obtain the water flow, showing also the elevation above sea-level of the land surface at which the boring starts.

Figure 20 shows in the darker areas, the western outcrop of the Dakota Sandstone in regions adjacent to the Rocky Mountain Range, and immediately into well known districts endemic to mottled enamel.

ORIGIN OF THE ARTESIAN WATERS.

The head or pressure that the artesian water has, must, according to physical laws, indicate that they originate in a region of much greater height or altitude above sea level than that of the artesian basin, and in discussing this question of origin Darton does so in this way in his Preliminary Report before quoted:

"There has been considerable speculation as to where the waters pass underground, but most geologists agree that the waters in the Dakota beds pass beneath the surface in the elevated region adjoining the Black Hills and Rocky Mountains. In these regions the Dakota beds are upturned and reach the surface (See Figure 20) so that they are accessible to the waters over considerable

in their passage across the Dakota (sandstone) and underlying formation in the Black Hills and Rocky Mountains have not in every case yielded definite results as to the amount of the water which sinks, yet it is clearly apparent that many of the streams diminish in volume before they pass out under the plains. * * * * * In the foothills of the Rocky Mountains

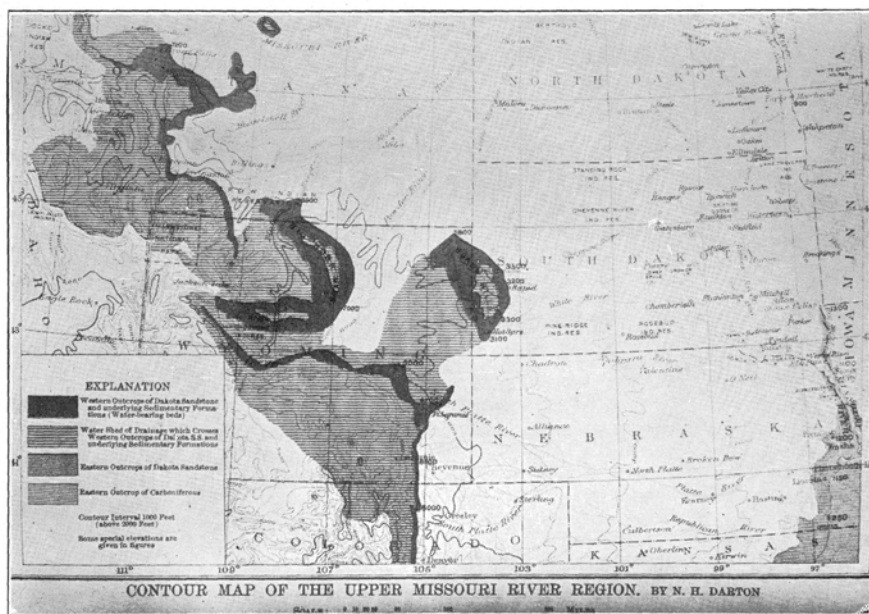


Figure 20.

areas. In these outcrops the formation consists of sands and porous sandstones, and much of the water that comes in contact with them is absorbed. The underlying formations are also more or less permeable, particularly the limestones, which are often cavernous, so that beneath the great mantle of clays lying above the Dakota (Sandstone) beds there are receptacles for large bodies of water, which, when they once have passed underground, are kept down by these impervious overlying materials. Altho studies of individual streams

there are many examples. As these waters enter the Dakota (sandstone) beds at altitudes upward of 3000 feet above sea level, we can readily understand the reason why the pressure is so great when they are tapped by wells in the relatively low lands eastward."

On this point Darton says further: "Part of the surface water passes into the sandstones in their elevated outcrop zones along the foot of the western mountains and flows east thru the permeable rocks, in most cases finally escaping in springs in the low level areas

of outcrop eastward and southward. In such water bearing strata as the Dakota (sandstone) and underlying beds, which are overlain by a thick mass of impermeable deposits, the waters are under great pressure, for the intake zone has an altitude of from 4,000 to 6,000 feet and the region of outflow is only from 1,000 to 1,200 feet above sea level. The existence of this pressure, as found in many wells in eastern South Dakota, is the strongest evidence we possess that the waters flow underground for many hundreds of miles."

It is probably true that were artesian wells sunk directly into the Dakota Sandstone in districts not far to the eastward of the Rocky Mountain Range, the same character of water as that obtained in the South Dakota wells would be encountered, "but the steep dips rapidly carry this formation to a great depth, so that it is beyond the reach of practical well-borings."

OUTCROPS OR EXPOSURES OF DAKOTA SANDSTONE IN COLORADO.

Darton, in his "Preliminary Report on the Geology and Underground Water Resources of the Central Great Plains" (Professional paper No. 32, U. S. Geol. Survey) gives elaborate and detailed descriptions of the extension and appearance of the Dakota Sandstone in various places adjacent to the eastern border of the great Rocky Mountain Uplift, and in going thru this material I find frequent instances where this formation thrusts itself up into the very heart of some of the well known and previously described endemic districts; but I wish here to attach no special significance to these circumstances, but to present them as evidence that this investigation seems entirely justified in assuming that this immense sheet of Dakota sandstone receives its water thru these upturned edges adjacent to the Rockies, and that this water finds its way eastward thru subterranean channels, to be tapped and

released thru the artesian wells of South Dakota.

It is indeed a curious and unexpected phase of our inquiry in which we can construct the hypothesis that some, unknown factor in the waters originating in the Rocky Mountain Range produces this lesion in certain adjacent localities, then the waters sink underground, travel at a great depth to the eastward and again rise to plague with this persistent influence, the children of man in unsuspecting communities at these distant points.

In regard to the origin of these waters, Darton has further to say (in private correspondence): "The artesian water of Eastern South Dakota undoubtedly passes underground in the Black Hills and Rocky Mountain slopes. It travels east at a rate of about one mile a year, so that about two hundred years may be required for the transit. The water at the places you mention all comes from the "Dakota" sandstone, which supplies all the artesian wells in the State, excepting a few shallower ones from a higher sandstone in the Mitchell region. The Dakota sandstone, however, is composite, with higher and lower flows from different sandstone members, and these flows differ considerably in chemical composition altho for that matter there are many differences in composition in the same flow at various places."

This helps to explain why so small a portion of the entire artesian districts (see Map Figure 18) is afflicted with mottled enamel,—practically only the northeast portion, as Martin, with an extensive acquaintance with the rest of the State, finds little knowledge of the existence of this lesion outside the vicinity examined, altho with the attention called to this condition by this investigation, it is altogether possible that a larger part of this artesian basin will be found to be afflicted. It should be remembered, however, that it is only since the building of the western extension of

the Chicago, Milwaukee and St. Paul Ry. from Aberdeen, a few years ago, that that section of the State has been favorable to population and the rearing of children to an age when mottled enamel could make its appearance. Martin recently reports that indications have come to him showing that this lesion is making its appearance in that newer section of the State, which when more fully settled, may be found to be of high endemic percentage.

Darton continuing, says that "The beds thru which underground waters pass vary in character from place to place, so that it is very natural that the waters from different beds and at different localities should vary."

Entering into such an inquiry as we have, concerning artesian water and its source, the natural question is whether the artesian water in other endemic districts previously described, comes from the same source.

The City of Alamosa, Colorado, in the San Louis Valley, has been described (Dental Cosmos, June, 1916, "D" page 641) as having about 50% affliction of native children, and the principal source of municipal supply is artesian. Located as it is, surrounded by the various ranges of the Rockies, there can be little doubt as to the origin of this water.

Amarillo, Texas, was also described as having a high percentage of affliction, and it also is an artesian district. (Dental Cosmos, July, 1916, "A" page 786).

The source of this water is at present not known, but Prof. Todd, then State Geologist of South Dakota, states the following (Geology and Water Resources of a Portion of Southeastern South Dakota, 1900): "Those who have studied the matter, universally agree that the main artesian supply is from the sandstone and sand beds of the Dakota formation. This remarkable formation is the source of water in Texas and Colorado, etc. It owes its efficiency to four conditions: (1) Its great extent, under-

lying most of the Great Plains from the Rocky Mountains to about the ninety-fifth meridian. (2) Its highly elevated western border, located in the moist regions of the mountains and crossed by numerous mountain streams. (3) The fact that it is extensively sealed in its eastern margin, by the overlapping clays of the Colorado formation, and where that is not the case, by the tile sheet of the Glacial epoch. (4) The excavation of wide areas, especially in (South) Dakota, by older streams so as to bring the land surface below the pressure height or "head" generated by the elevated western border of the formation."

FRAGMENTARY EVIDENCE OF OTHER ENDEMIC REGIONS.

Dr. Arthur G. Rand, Nantucket, Mass., states that "in certain parts of the Azores and Cape Verde Islands, off the West Coast of Africa, this condition exists, mostly in a race of people called the Brava, and that their teeth are nearly the color of their faces," meaning, I presume, that they are a colored race.

These Islands, being possessions of Portugal, I have tried to get into touch with avenues for further information thru the Portuguese Legation at Washington, thence at Lisbon, but conditions in Europe and on the ocean have, for the present, prevented.

It is also possible that certain districts in western Minnesota, just east of the artesian basin of South Dakota, share the same conditions, due possibly, to an extension of the basin. Such a condition was reported by Dr. M. Williams, from Wheaton, Minn., by letter in the Dental Cosmos, February, 1917. The report is of doubtful accuracy, however.

Definite report, however, has been made (Transactions of Panama Pacific Dental Congress, San Francisco, 1915) in discussion of a paper by myself, of an afflicted district at Bishop and Benton, California, which are located in the east central part of the State. I have

not been able to get any further information from this district and feel that a detailed examination would later be warranted.

OTHER ARTESIAN DISTRICTS SUSPECTED OF BEING ENDEMIC TO MOTTLED ENAMEL.

Certain other publications of the United States Geological Survey (particularly—Ground Water in San Joaquin Valley, California—Mendenhall; Dole and Stabler) indicate that parts of this region are to be looked upon as bearing, from the standpoint of character and source of the water supply, suspicious evidence of being endemic to mottled enamel, but without examination or other clinical evidence from the district, no facts are at hand.

Certain other artesian districts in Colorado have recently come to my notice, which, according to my best information at present, received their flow from the Dakota sandstone. It may be of importance later, to determine by examination, whether mottled enamel exists there.

THE RELATION OF THE ARTESIAN DISTRICT IN VIRGINIA.

My readers will probably not need to be reminded that, as reported in a previous article (*Dental Cosmos*, June, 1916, page 643) mottled enamel was found associated closely with artesian water at Franklin and Courtland, Va. It is important therefore, that the same careful chemical examination be made of that water, in comparison with the analyses of related waters from the other districts.

AN ENDEMIC REGION IN THE BAHAMA ISLANDS.

By far one of the most interesting phases that this investigation has assumed, is finding this lesion existing in this group of Islands, located in the Atlantic, about 200 miles east of Florida.

This was brought to my attention by

Dr. G. H. Johnson, of Nassau, on the Island of New Providence, one of the group. He describes conditions as follows; "I have observed the conditions described by you, in several islands of the Bahama group, while other islands are free from any trace of such trouble. Every person, white and black, whom I have seen from Rum Cay and Watling's island, is afflicted, to a greater or less degree, and nearly everyone from Ragged Island. On some of the islands near these, the trouble is sometimes seen to a slight extent. The Northwestern islands of the group, viz.: Abaco, Eleuthera, New Providence and others, are free from any trace, except in fishing villages on Eleuthera, from which I have seen a few mild cases." (See map, Figure 21.)

Dr. Johnson sent me two teeth, extracted from a colored person who was born and lived until sixteen years of age on one of the Islands (Rum Cay)—upon which this trouble is prevalent.

Figure 22 is introduced principally to illustrate this lesion as it appears in the Bahama Islands (Nos. 4 & 5) showing a pitted or "corroded" condition of the enamel. (Teeth furnished by Dr. Johnson.)

It has been stated before that this lesion always assumes the same typical appearance, varying only in degree, regardless of the geographical district wherein it exists, and this illustration bears out the statement and argues the same cause, operating in the same way upon the enamel structure in the various endemic districts.

To continue, however, with Dr. Johnson's description: He describes a boy of 19 years from the same Island, whose teeth were even more discolored, even the second molars being pitted and discolored.

Because of what has been said regarding the water in other districts, let us consider this question in the Bahamas. Dr. Johnson says: "The water is obtained from wells of a depth of 5 or 6

feet. The water contains a large proportion of lime which it gathers after falling, by filtering thru the limestone of which the islands are formed. This fresh water in the wells, rests upon the salt, or ocean water, which is in the rocks, rising and falling in the wells, with the tides. Being rain water, the wells are at a lower level in dry seasons, but the tidal rise and fall

If this be the case, then it argues that if the water be the cause of this lesion, it is because of something it takes from the soil, since water which does not come into contact with the soil (rain water gathered into tanks) is unassociated with mottled enamel. If the date presented in this paper has been considered conclusive, these conclusions might seem to have been shattered by the conditions

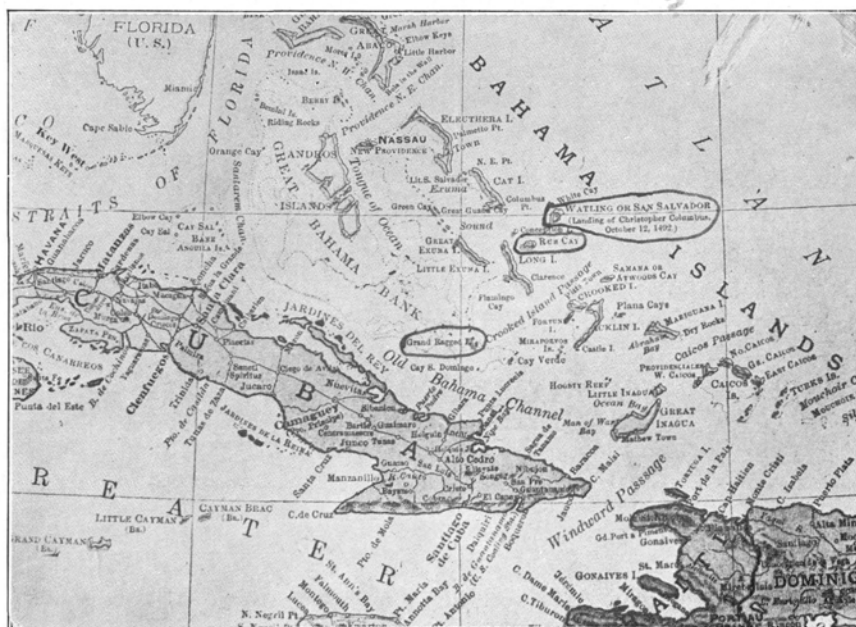


Figure 21.
Map of Bahama Islands.

is noted in all seasons. Further; if much water is taken from a well the water which flows in to replace it is much "harder" (that is, higher in mineral content) than that which has been taken out, and the water returns to its original degree of softness after the well has "rested." On a few of the islands, spring (meaning 'well') water cannot be obtained; here the water supply consists of rain water caught and stored in stone tanks. On these islands I have never seen a case of mottled or stained teeth."

just described in the Bahama Islands, for it is difficult to understand what relation can exist between water obtained from the shallow wells in these limestone coral islands, in the ocean, and that flowing from the Rocky Mountain Range, hundreds of miles underground, to supply deep artesian wells far in the interior of the country. Undoubtedly it strengthens the attitude we have taken in directing the study of this problem, that the only way a solution can be

reached is by a most careful comparative chemical determination of the waters.

This would be a difficult matter in these Islands, inasmuch as they are not easily accessible, and because the means of communication among the several afflicted and immune islands, is limited to small sailing vessels at irregular intervals. I believe, however, that the data secured by a close examination, would prove extremely valuable and conclusive, after this investigation has reached a point where such data could be correlated with what had previously been determined.

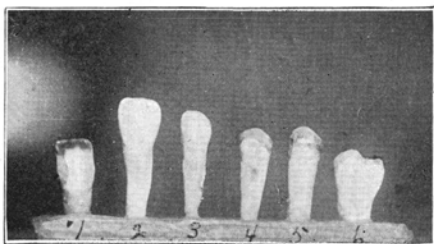


Figure 22.

Mottled teeth from various districts, as follows: 1-3-6, Colorado; 2, Texas; 4-5, Bahama Islands.

One of the difficult features in the study of this problem has been the great distances which had to be traveled in order to personally inspect these widely separated districts, to guard against error.

A CONSIDERATION OF THE INFLUENCE OF THE DUCTLESS GLANDS UPON THE CALCIFICATION OF THE TEETH.

Of late years medical literature has been dealing more and more extensively with various dystrophies that have been found to be dependent upon disturbed functioning of these ductless glands, and various references to abnormal dental conditions are to be found.

Inasmuch as we may later find that our lesion can be brought into a closer relationship with the disturbances just mentioned, and also because such a re-

lationship is already believed to exist by many whose opinions are usually accepted with deference, it is necessary at this time to give this matter at least brief consideration.

So far as I can at present observe, this relationship is based upon two groups of circumstances: (1) The occurrence of malposed and malformed teeth in individuals who also exhibit marked gross physical evidences of various kinds, illustrative of disturbed secretional function. (2) The occurrence of teeth that are themselves more or less grossly malformed or undeveloped, and found either in individuals similar to those mentioned under (1) or in criminals in whom certain glands, usually the parathyroids have been experimentally removed.

Perhaps these effects upon the teeth have not been recognized to the full extent, or less imperfectly observed, but the fact is that I find in a limited examination of such literature, including recent books, however, very meagre reference to disturbances of the dental structures.

In considering endemic cretinism, Krantz reports that in an examination of thirty cretins in an institution, he found "numerous anomalies of the jaws, retarded teething, besides factors that give occasion to anomalies of the position of the teeth." (Ductless Glandular Diseases Falta—Meyers.)

Certainly such evidence as this cannot be considered as anything but incomplete and inconclusive. It would be easy to duplicate such findings in almost any group of institutional children.

Describing his findings further, he mentions "alterations of the structure, defects of the enamel, hypoplasias and erosions, and very frequently caries."

Erdheim's observations upon rats, after the parathyroid glands had been removed, described changes in the structure of the enamel, and even defects in the enamel.

In brief, I cannot but conclude that none of these defects or alterations of structure as described in recent texts, are any different than those gross defects of enamel and dentine that have been long recognized and formerly spoken of as atrophies, but post-humously named by Black "Contemporaneous Accretional Deformity" or "Lineal Deformity," which he describes as a "deformity occurring along the lines of accretion, contemporaneously in all teeth in process of development during a period of malnutrition." (*Mottled Teeth*, etc., G. V. Black, Dental Cosmos, February, 1916.)

Following this thought it is easy to see that were the period of malnutrition continuous and prolonged thru dental development, as would be the case in the glandular disturbances, then gross deformities of the teeth would be the result expected.

If mottled enamel were the result of glandular dystrophy, it would seem reasonable to expect to find the other typical symptoms at least among the natives of the various endemic localities, but such is certainly not the case insofar as our present knowledge goes. Given a district wherein the percentage of mottled enamel among natives is actually 100, would we not reasonably expect at least an appreciable proportion of these to show some signs of glandular disturbance, if it were the real factor?

The one circumstance connected with glandular dystrophy that exists in common with mottled enamel, is its sharply defined geographical location in various parts of the globe.

I find in Falta's Book certain statements bearing upon the distribution of cretinic degeneration, that are worth quoting. In certain parts of Europe, "especially in the Central Alps, large goitrous districts exist; also in other parts of the earth the goitre districts lie in mountainous districts, and these districts change; localities that were for-

merly infested become goitre free, and conversely."

Interesting instances are given of families whose children born outside the goitre districts were healthy, but those born in the goitre districts had goitre. There is an element of similarity between such a circumstance and the behavior of mottled enamel. He states further that "enormous outbreaks of goitre have been often observed in regiments after their stationing in goitre districts."

The authorities on this subject seem to have concluded somewhat definitely that the cause of this condition is in the water, altho at present undetermined, and the following quotation gives the basis of the theory:

"The noxus of goitre is found in the drinking water. In the goitre territory there exist indeed especial goitre brooks; there are numerous examples in the literature of goitrous communities becoming free of goitre after they had established drinking water conduits from goitre-free vicinities." (Falta.)

This has a familiar sound to us in this work on mottled enamel, and we recall the instance of LaFayette, Colorado, which has produced immunity from mottled enamel by changing from shallow wells to mountain water, while per contra, in the Virginia field the change from shallow wells to artesian water has brought affliction; the same is true in South Dakota. Verily we seem to be dealing with a sword of double edge.

The unknown noxus of goitre is not filterable, and is destroyed by a temperature higher than 70 degrees C, which brings the conclusion that it is likely it is not a miasma but a toxin or toxalbumin from an organic substance. This might suggest that the hidden factor for which we are searching in our problem is a toxic or a bacterial element which has heretofore not been thought to be the cause.

So far as organic factors are con-

cerned, it should be remembered that in some of the water analyses previously published, there was hardly a trace of organic matter. However, if in this cursory argument I might seem to be trying to discredit the glandular hypothesis, I wish now to consider the views of Prof. John E. Greves, of Utrecht, Holland, who is decidedly of the opinion that thyroid disturbance, or at least underlying constitutional factors, will be found to contain the solution of the difficulty.

After having received from me some specimens of mottled teeth, he states

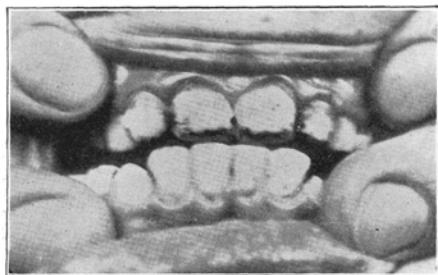


Figure 23.

without reserve that he is familiar with the same condition in Holland, except that the brown discoloration is not so common, and he sends the following photograph (Figure 23) to bear out his assertion, altho this case has also the stain. The boy is a native of Utrecht.

Hardly a day passes, he states, that they do not see these cases in the clinic at the University of Utrecht.

Speaking of the water, he says that the drinking water used at Utrecht is noted for producing goitre, and that frequently students have to discontinue their courses and leave on account of it. He finds it difficult to believe that the drinking of the water as found in the various localities in America, *alone* brings about mottling of the enamel, and thinks there must be a deeper cause, some constitutional con-

dition, however slight, such as affections of the parathyroids particularly, or other glands giving out internal secretions that play an important role in our cases. He and his colleagues have been conducting a series of studies upon rats, and he furnishes me with the following photograph and description:

Group 1. "Rats fed on bread and water from the sand hills dune water—as is used in Amsterdam, only carbonic acid is added artificially in bottles. The Thyroid Gland is little changed. The teeth however, are very brittle, and several are broken during life. The parents were fed for three months on bread and also sparkling (carbonized?) dune water (from the sand dunes.) Microscopic sections of the dentine show abundance of inter-globular spaces."

Group II. "Rats fed on *unboiled* Utrecht water. Parents fed on bread and milk. After three weeks the young ones were given Utrecht unboiled water. The Thyroid gland shows enlargement as result of this feeding, and teeth are growing irregular with large inter-globular spaces in the dentine."

Group III. "Rats given *boiled* Utrecht water three weeks after birth. Microscopically the dentine is very irregularly formed, but the enamel shows not much difference. There is a very great enlargement of the thyroid gland and very much irregularity in the growth of the incisors."

"In comparing the teeth of these rats with those of wild rats, one is struck with the whiteness and absence of lustre."

This description resembles that of mottled enamel in the opaque whiteness, and if it be the same it is the first time to my knowledge that this lesion has been produced artificially in the lower animals. Grevers considers his studies therefore, only the beginning, and we may hope for future developments.

The great difference that I can see in the results produced by Grevers is that

gross or macroscopic alterations in the entire form and structure of the teeth have been produced, while in the lesion we have been studying, the dystrophy is

cates a deficiency of the interprismatic substance, i. e. the enamel rods are not bound by a cementing substance.

He is not quite in agreement with

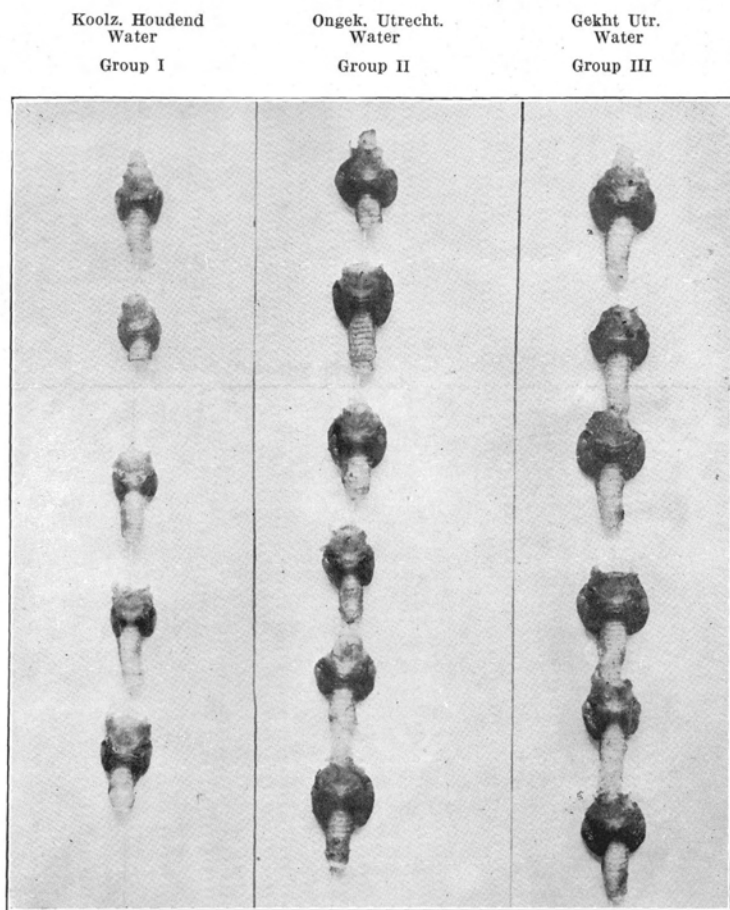


Figure 24.

confined to the enamel, and the alteration of structure is mainly microscopic.

Grevers however, upon receiving specimens from me, made a comparison with sections of mottled teeth from his own locality, and found, as he states, exactly the same conditions as those in the American teeth. In describing these he reviews Black's theory that the opaque white covering of enamel indi-

cates a deficiency of the interprismatic substance, i. e. the enamel rods are not bound by a cementing substance. He is not quite in agreement with this theory, for, he states he "has found that this outer part of the enamel (in the mottled teeth) is in the same condition that enamel is normally found before the teeth are erupted, while still within the bony crypts."

Continuing he says, "When I treat my slides (of the unerupted teeth) with coloring matter (Thionin) the outer part of the enamel takes up the stain, whereas

the mature enamel (underlying) refuses the stain. This I find the case with immature enamel always, and now comes the interesting part of my investigation, viz.—mature enamel is negative (turns the light to the right) and immature enamel positive (turns the light to the left) under the microscope—using polarized light. This is exactly what I have found to be the case in my specimens of mottled teeth.”

His conclusion therefore, is that mottled enamel is simply immature or not fully calcified enamel, and not an inherent lack of the cementing substance.

That this conclusion, coming from an

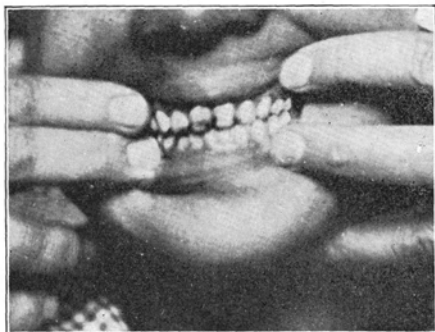


Figure 25.

During an examination of the inmates of the Sherman Indian School at Riverside, California, made during the year by Drs. Ketcham and Gray, several cases of mottled enamel with the brown stain were found, every one of whom proved to be from the Pima Reservation in Arizona. Illustration of two of these are shown in Figures 25 and 26.

On the other hand, in an examination of over 4200 Indians of the Navajo and Hopi families, made by L. H. Curran, M. D., U. S. Indian Service, Moqui Indian Reservation, Oraibi, Arizona, over a territory of about 200 miles, he reports these Indians to be totally immune.

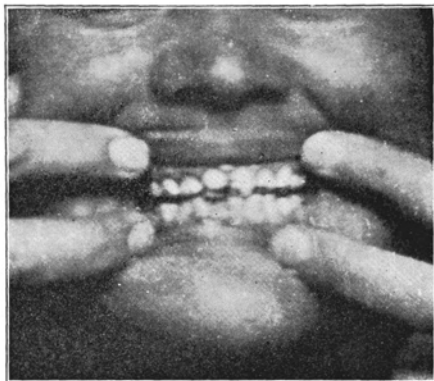


Figure 26.

investigator of Grever's experience, is worthy of our consideration, goes without saying, but be it as it may, the real problem remains unchanged, and that is to locate the influence which either prevents the maturing of the outer layers of the enamel, or else partially destroys this layer after it has once been fully formed. Which of these two hypotheses, if either, will finally be found to be correct, it is impossible at present to say.

FURTHER EVIDENCE SHOWING THE EXISTENCE OF MOTTLED ENAMEL AMONG THE PIMA INDIANS.

As reported in *Dental Cosmos* (August, 1916,) the Pima Indians were found to be highly afflicted.

He reports however, that among the Southern Utes, at Ignacio, Colorado, the condition of mottled enamel is very pronounced, which as yet has not been confirmed.

ADDITIONAL EVIDENCE CONCERNING A PROBABLE ENDEMIC DISTRICT AT WACO, TEXAS.

In *Dental Cosmos* (July, 1916, page 786) is illustrated a case native to Waco, Texas.

Dr. F. C. Watson, Lake Charles, La., reports a case coming under his notice who gives a history of having been born in Waco, and curiously enough, reports having been raised upon artesian water. The entire denture is mottled with stain-

ing of the upper incisors in the characteristic way. The case is illustrated in Figure 27.

A CRITICAL REVIEW OF AN ITALIAN INVESTIGATION OF "MOTTLED ENAMEL" CONDUCTED NEAR ROME.

A Digest appearing in "Chemical Abstracts" (June 20, 1916,) drew attention to an article published in "Annali di Chimica Applicata," Rome, Italy (Vol. 5, 1916,) by Gasparrini and Piergili, under the title—"Decalcifying Action of Certain Drinking Waters on the Enamel of the Teeth in the Period of Dentition." Rome, December 1915, which describes a lesion of the enamel, the physical characteristics, and mode of occurrence of which leaves little doubt that it is precisely the same as that with which our investigation has dealt in various parts of the country.

A translation of the original article was prepared by Mr. Chas. A. Baldwin, of Colorado Springs, and in order that we may contrast the Italian view point with the larger field covered during our investigation in America, I deem it of interest to enter into a critical comparison of their conclusions with our own.

The authors describe in the first part of the paper, various methods which they have used for bleaching and removing various anomalies of color of the teeth due to metallic stains, and of pulpless teeth. Coming closer to our problem these authors say: "Most brilliant results were obtained in teeth commonly called 'scritti' ('denti scritti—teeth written upon'). (See Dental Cosmos July, 1916, page 785,) which present furrows or yellow striations alternate with lines of decalcified (?) enamel."

"The first case, a very fine one, referred to me by Chiavaro, was an individual who was going to the Polyclinic for the care of disease of the gums."

"It was believed that on account of the supposed congenital nature of the condition that it was impossible to whiten enamel of that sort. The young man V. of S., who was a native of Santa Maria, had teeth which presented mostly dark yellow lines, scattered with white opaque spots, which condition was common to all living in his neighborhood or district."

This would indicate that Santa Maria is an endemic district, in that a consid-

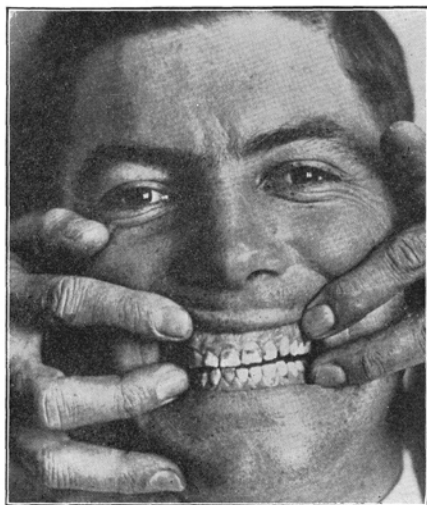


Figure 27.

Waco Case.

erable number of its natives are constantly afflicted with this condition.

To resume: "I made the treatment (for removal) on the left side, so as better to be able to notice the progressive result. After fifteen treatments this part had acquired the normal color and translucency, making a most marked contrast with the untreated part. Such a result, with control by Chiavaro, and by many other professional men in Rome was noteworthy for me from the scientific point of view, especially in the disappearance of the white opaque spots,

which must therefore be altogether superficial."

In this respect and in this conclusion, Gasparrini is in precise accord with repeated experiments made by us, in that after removal of the superficial opaque layers of the enamel which carry the deposit of "brownin," normal enamel is found immediately underlying.

Indeed there is no question remaining at the present time but that the defective enamel is absolutely limited to the external layers of the teeth, except that as shown in Black's histological sections (*Dental Cosmos* Feb., 1916,) the defect may, at certain points, dip into the deeper layers of the enamel. Such spots would be invisible to the unaided eye, particularly in the presence of moisture.

To continue: "After numerous other experiments of this kind, which I carried on in the laboratory of Piergili and elsewhere, and which always confirmed the first result, the idea arose that a work should be undertaken to discover the origin of such anomalies, of which none up to this time, had given a convincing explanation, and which were considered generally to be of congenital origin."

Gasparrini then appends the following, by his collaborator, which deals more intimately with the problem.

"It is known that in some districts (or localities) the inhabitants almost without exception, have their teeth marked with yellow and white spots (*denti scritti*.)" "It was most common to see these teeth at Capua and at Naples before the water of the Serino was brought in."

It will be recalled that Dr. Eager, of U. S. Marine Hospital Service, noted this condition at and near Naples (*Dental Cosmos*, March, 1902,) as reported by me in *Dental Cosmos* (July, 1916, page 785) under the name "Chiaiae Teeth."

Associating this condition of the teeth

in the Italian Investigation with a change in the water supply, is of intense interest to us, as we have noted frequently in what has been published previously that the occurrence of this lesion seemed to be so closely allied with a change in the water supply in different districts, notably at LaFayette and Walsenburg, Colorado, Franklin and Courtland, Va., and as reported in this article, in the artesian districts of South Dakota.

It is of interest to note also that the Italian investigation goes immediately to the water supply as the suspected origin of the trouble.

The Italian article we are reviewing, states also, in almost our own exact words, that "The discoloration presents itself everywhere in the same way, for which the cause must be identical." Continuing, the article says: "We made local observations at Campagnano at Rome, where the phenomenon is very marked. The first dentition of all the children of Campagnano takes place and maintains itself normally. The second teeth appear healthy, but suddenly lose their translucency and become of white opaque color. Successively corruptions, colored yellow, begin. Inhabitants who have gone away at the period of the second dentition, even if born at Campagnano, and of native parents, have normal teeth. On the other hand, those not native, and born of parents not native to Campagnano, but who have come to that district at the period of the second dentition, have teeth which are corroded and discolored."

This recital of conditions is remarkably similar to our own in describing the behavior of mottled enamel toward natives of the various endemic districts of America, and also toward those who altho not native to any of these districts, have grown the enamel of the permanent teeth therein, regardless of parentage and indeed of all other conditions except actual residence in such

districts. Gasparrini points out that the temporary teeth are always normal, but his statement that "the second teeth suddenly lose their translucency and become of white opaque color," can hardly be accepted as an accurate observation, for the reason that it is settled beyond any question of doubt in our experience, that the teeth erupt with the enamel of this typical opaque, white and mottled appearance with which he seems familiar.

My own observations have shown time without number, that exfoliation of temporary molars, after complete absorption of the roots, will show the occlusal surface of the oncoming bicuspid plainly visible and covered with this typical opaque white enamel. The same is true of erupting teeth in general among natives of afflicted districts.

With reference to the brown stain, I understand Gasparrini to mean that this discoloration, which the translator has termed "corrosion," makes its appearance after the eruption of the teeth, in which respect we are in entire harmony of understanding.

Continuing, he emphasizes his conclusion thus: "*These facts prove that the anomaly is not congenital, but is acquired in the period of second dentition.*"

Inasmuch as his conclusions, later shown, seem to mean that we should take the above quotation literally, I find myself in disharmony, to the extent that I would change the meaning to read: "but is acquired or brought about during the period of enamel development of the permanent teeth, and prior to their eruption," having reference strictly to the mottling of the enamel.

To continue: "Various hypotheses have been formed to explain the phenomenon, but two especially are worthy of discussion."

"1. Action of the air and the humidity."

"2. Action of drinking waters."

The first he discusses as entirely untenable, but considers the second at some length, from which I abstract the following:

"In favor of this theory it is a fact that in the first dentition, in which the child drinks milk, no anomaly takes place, but on the other hand, appears in the second dentition, that is to say, when a normal use is made of water."

It would seem to us that our author has missed the point. The true explanation of the immunity of the temporary teeth undoubtedly lies in the fact that their enamel is formed largely before birth, under conditions wherein the structural elements are presented after dialysis thru the placental membranes.

Coming now to a direct consideration of the drinking water:

"The waters of Anguillara, of Santa Maria and of Campagnano were analyzed, three districts in which the inhabitants are afflicted by this disease; but the qualitative chemical analysis did not give unusual results."

"The quantitative analysis however, showed a minimum content of mineral salts in general, but of salts of calcium in particular. They are therefore, waters relatively very pure."

"We now affirm that this minimum content of calcium salts is the cause of the phenomenon, altogether local, and due to the contact of the water with the teeth."

From the American viewpoint this theory that the lesion is due to a lack of calcium salts in the water, has a familiar sound, as this was the prevailing theory here before this investigation had collected its data.

It is unfortunate that these authors did not include their analyses in their paper, as a comparison with those made in the progress of our work would have been most interesting.

It is a fact that in the American endemic districts the waters have been

lacking in "mineral salts in general and in calcium salts in particular." Let us review some of the analyses published in our article in the dental Cosmos (May to August, 1916.)

The water of "L" with an endemic percentage of 88, has a total solid content of 57 plus, parts per million, with a calcium content of 5.7. This is a remarkably pure water, with a very low calcium content.

In contrast with this is the water at "V" with total solids at 1429. per million and calcium content of 90.

The endemic percentage of "V" is practically 100 and yet this water is certainly very high in mineral content, and carries fifteen times as much lime as that at "L."

As set forth in our previous article, as referred to, the conclusion is evident that judging the analyses at their face value, the solid content and the proportionate lime content of these waters were then considered to be absolutely contradictory as furnishing a reliable guide in determining the cause of this lesion. Our work along that line however, is by no means complete at the present time, so let us follow the Italian article further.

"Meanwhile we notice that the alteration of the enamel is superficial, as we have seen by our system of treating the teeth, which succeeds in eliminating the opaque white stratum, under which is found enamel translucent and normal. This demonstrates that the cause which produces this anomaly is external. If it were internal—if these waters acting on the organism—(hypothesis not to be excluded a priori) did not permit the complete calcifying of the enamel, all the underlying strata of the enamel would be abnormal, but the above mentioned experiments show that only the external stratum is changed."

"There remains then to explain the local action of these waters upon the teeth in the period of the second dentition. In favor of this local action the fact militates that the most affected are the superior incisors—the teeth most in contact with the water in drinking."

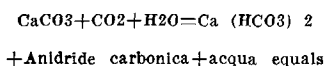
Gasparrini here attempts to set up the theory that the contact of certain waters against the labial surfaces of the upper central incisors produces this lesion. Does he have reference to the brown discoloration only, or to the mottled condition of the enamel? If the former, it is true that these surfaces are sometimes the only ones showing the stain, and usually the ones most marked, but what shall we say of those cases in which the entire denture, including the third molars, are stained almost a chocolate color, which have been seen in our experience?

Surely a water which was powerful enough to produce such a change by mere contact with, or laving of the teeth, would hardly have its action limited to or exhausted by so small an area of the denture, and surely so powerful a water would exert some similar influence upon the rest of the teeth.

If he ascribes the mottling of the enamel to the surface contact with these waters only, why would not such water attack the enamel of non-natives as well as natives and produce the same result? His explanation continues:

"But to make clear the chemical action which takes place, we must hark back to the origin of the salts of calcium in drinking waters taken from springs, as it is known these come from rain waters, lacking, as a rule, in mineral salts, but rich in carbonic anhydride. Crossing thru soil in which lime abounds (an insoluble neutral carbonate of lime) they act slowly thru the following reaction:

Carbonata neutro
di
Calcio (insoluble)



Carbonato acido
di
Calcio (soluble)

"And so, the carbonate of calcium (insoluble) passes in solution under the form of bicarbonate (soluble.)"

"Naturally the tendency which rain water has to carry off lime in the form of bicarbonate, is all the greater, other conditions being equal, the less the quantity which it already contains in solution. A water very rich in salts of calcium will have therefore, a minimum tendency, or none at all, while a water with a small content of these salts will have to a very great degree, the property of absorbing it." (Lime.)

"Now the enamel of the teeth, which has a high content of salts of calcium, in contact with drinking water poor in these salts undergoes *superficially a decalcification*, and thence an alteration."

"To the question as to why these waters do not act on the teeth during any other period of life except only at the time of their eruption, we would answer, citing the following fact in nature."

"Building stones (travertino, marble, granite, etc.,) while in the quarry present very little resistance to the physical and chemical agencies; so much so that they are easily worked. Exposed for some time to the air, they acquire that resistance and specific hardness which is peculiar to them."

"The enamel of the teeth, by composition and inherent properties, is very similar to minerals. Given the great loss of water which enamel undergoes upon eruption and immediately afterward, this substance presents an analogous condition with the minerals above mentioned. With exposure to the air its specific resistance will increase, while after a short time the decalcifying action of these waters will become null."

Gasparrini's deductions seem anything but convincing to us.

To continue: "Thus the fact remains perfectly evident that nothing abnormal is noticed in the first dentition which takes place (erupts?) when the child drinks milk."

Concerning this question of the use of milk it will be recalled from my previous article that the Pima Indian children, in whom this enamel lesion is universally prevalent, have no facilities for the use of milk, nor do they use any, and it must be a fact that water is drunk during early childhood, yet the temporary teeth are normal, but the permanent teeth very badly marked.

Resuming: "We will explain how these waters do not produce any harmful effects upon the teeth of the second dentition when contact is lacking during the first period of their eruption." (I assume G. means to explain the failure of these waters to act upon teeth which have already erupted.)

"Just as the upper incisors are for a longer time and more completely immersed in the water when the glass is carried to the mouth, they are the ones most affected or altered."

"The phenomenon of 'denti scritti' (literally "teeth written upon"—meaning irregularly stained or striated) is rarely produced by spring water, because in the ground, lime abounds and the rain water crossing over and thru diverse soils could scarcely succeed in remaining relatively poor in salts of calcium. It is more frequent in those who drink cistern water."

Much could be said in answer to these arguments, but I will call attention briefly to certain points only. One of the most localized endemic spots with which our investigation has dealt, is the Sigle Ranch in Colorado, and here the water has been derived from a spring of unexcelled purity and low total solid content. This paper reports certain Islands in the Bahama group, as being endemic, and we found that the source of water was shallow wells. These Islands are coral reefs, in other words, solid calcareous material. What shall we say of rain water with reference to its lime content after running over and thru such a soil?

As to cistern water, it has never been our experience in a large and exceedingly diverse territory examined during the investigation, to find any association of this lesion with cistern water.

Were we to pursue our critical analysis of the Italian investigation further, additional contradictory evidence, particularly regarding water conditions and contents, could be produced, but it seems to us that our author's conception of this lesion and its production is faulty in its first fundamental, and we cannot understand how they, with their dental collaborators, have evidently failed to notice that teeth which have mottled enamel, erupt with the enamel in this condition, which means that this is brought about during the developmental period, and before the enamel could possibly have been in contact with any

water which passed thru the mouth during the act of drinking.

We feel, as we always have, that the damage is wrought by some influence which acts either in an inhibitory or in a destructive way upon the enamel during or immediately after the building period, and reiterate that the condition is established prior to eruption.

However, since this study of these authors is the only other study similar to our own that we know of, it is received with great interest and as entirely worthy of such analysis as we have given to it. Their article closes with an announcement that "The phenomenon of corrosions with dark yellow discolorations, which manifest themselves after decalcification will be the subject of another paper at an early date"—and we sincerely hope that the same may be brought to our attention.
