

Proceedings of the Iowa Academy of Science

Volume 40 | Annual Issue

Article 45

1933

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Recommended Citation

Ostrem, Carl T.; Greenwood, D. A.; Wilhelm, H. A.; and Nelson, Victor E. (1933) "The Occurrence of Mottled Enamel in Iowa," *Proceedings of the Iowa Academy of Science*, 40(1), 99-102.

Available at: <https://scholarworks.uni.edu/pias/vol40/iss1/45>

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THE OCCURRENCE OF MOTTLED ENAMEL IN IOWA ¹

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Mottled enamel is a peculiar condition of the teeth. The teeth become chalky white in appearance and lack the lustre and translucency observed in the enamel of normal teeth. They are generally stained in an irregular manner and the dark brown stain supposedly accumulates between the enamel rods. However, some individuals have severe mottling of the enamel with little or no stain. We do not know the nature of the substance responsible for the stain. The teeth become soft and the dentist experiences difficulty with the teeth retaining fillings. It is not known for certain if mottled teeth decay more readily than normal teeth, but some dentists assert that when dental caries starts in mottled teeth it is difficult to control the process.

This condition has been observed in various parts of the world. It is found in China, Japan, Africa, Italy, Holland, Spain, England, Argentina, Mexico, and the United States. The following states have reported the occurrence of this lesion: Washington, Oregon, California, Nevada, Idaho, Arizona, New Mexico, Texas, Arkansas, Oklahoma, Colorado, Kansas, North and South Dakota, Minnesota, Illinois, West Virginia, and South Carolina. Black and McKay (1) in 1916 were among the first who called attention to mottled teeth in certain areas of this country. They observed it in certain communities of Colorado. As a matter of fact the condition is most prevalent in certain regions in the states of the southwest. Black and McKay at this time attempted to ascertain the cause of the trouble and they suspected some relationship between the drinking water of those regions and the condition of the enamel. However, they had no conception how the water might be responsible for the effect on the teeth. Until recently no common characteristic of the waters from affected regions had been observed, and, consequently, the causal agent of the disturbance in the structure of the teeth remained unknown.

Churchill (2) has analyzed waters from different sections of this country and found fluorine in a considerable number. In this connection Churchill states: "It is well to emphasize the fact that no precise correlation between the fluoride content of these waters and the mottled enamel has been established. All that is shown is

¹ Read at general meeting of the Academy.

the presence of a hitherto unsuspected common constituent of the waters from endemic areas. However, it is of interest to note that apparently the relative severity of the defect in these various areas seems to follow the fluoride concentration." Churchill appears to be the first to call attention to the presence of fluorine in drinking waters in various parts of the country.

Smith, Lantz, and Smith (3) of the University of Arizona have shown that the tooth defect is due to fluorides in the drinking water; they have analyzed the fluoride content of water in endemic areas and found it to be high. Furthermore, they have produced a similar condition in the teeth of rats, guinea pigs, and dogs by feeding small amounts (0.05 and 0.025 percent) sodium fluoride. There are about forty-five communities in Arizona in which mottled teeth are prevalent. Prior to the work of Smith and co-workers there appeared in the literature evidence that small amounts of fluoride in the ration caused a detrimental effect on the teeth of rats. Schulz and Lamb (4), for instance, fed rats sodium fluoride varying in amount from 0.001 percent to 0.25 percent of the ration and found that no ill effects on growth resulted until 0.10 percent or more of NaF was fed. They state that a very marked toxic effect is observed when 0.15 percent to 0.25 percent is present in the diet. They observed that an unfavorable effect on reproduction begins at a level of about 0.025 percent of sodium fluoride in the diet. McCollum, Simmonds, Becker, and Bunting (5) found that fluorine caused an abnormal development of the teeth and bones of the rat. They state "From the results obtained in this experiment it appears that fluorine may play an important part in dental and osseous development and that the administration of that substance in excess of the normal requirement may have a retrograde rather than a stimulative effect on calcification."

Dr. Carl T. Ostrem of Ankeny, Polk County, Iowa, recently called the attention of Professor V. E. Nelson, of Iowa State College, to a condition existing in that region which corresponds exactly to the description of mottled teeth in the literature. How extensive this area is we do not know. However, a large number of the native children of this vicinity have mottled teeth. Examinations of the teeth of the children of the community show that all native children that have habitually consumed this water have mottled teeth. It is possible that the trouble began after the sinking of deep wells in this region and that the condition did not occur while shallow well water was used. The evidence for this is that the cases so far noted have occurred in children born at approximately the time when the deep wells were installed. Several cases

of mottling in deciduous teeth have been observed but as a rule it is confined primarily to the permanent teeth.

The drinking water of Ankeny has been analyzed both spectrographically and by the Churchill modification of the Fairchild method (2). This later method consists in adding a definite amount of ferric chloride to water together with KI and HCl. Iodine is liberated and titrated with standard thiosulphate. If fluorine is present it will combine with the iron to form ferric fluoride which will not liberate iodine. The results show ten parts of fluorine per million of water. The characteristic calcium fluoride band in the spectrum eliminates all doubt as to the presence of fluorine in this water supply. A sample of water from a farm in the immediate vicinity of Ankeny showed the presence of fifteen parts of fluorine per million. These waters are from deep wells. The waters from shallow wells in this region gave qualitative tests for fluorine as did the water from the college supply but the amount (about 0.50 part per million) is insufficient to cause mottling of the teeth. The Arizona investigators (3) state that from two to three parts per million of fluorine is the minimum amount that will produce this effect on the teeth.

Rats fed a good growing ration together with water from Ankeny and the farm nearby developed mottled teeth. The teeth became blanché and irregular in shape. Rat's teeth differ from human teeth in that they have a persistent pulp which simply means that they continue to grow. They continually form enamel. The teeth are worn away by contact with each other and food or by gnawing but new tooth tissue is being formed so that the teeth have a definite length. Consequently mature rats will develop mottled enamel whereas mature human beings do not do so. Once the teeth have been formed in human beings no further development of the enamel occurs. It represents an inert tissue and is therefore not modified by inclusion of fluorides in the diet. However, fluorides, if present in the diet, will have the characteristic effect on the development of the enamel during the stage of the formation of the enamel rods of the permanent teeth by the enamel organ, or more specifically the ameloblasts. Fluorine is present in the bones and teeth probably as fluorapatite $\text{Ca}_5\text{F}(\text{PO}_4)_3$, and it is probable that the enamel of teeth is a mixture of $\text{Ca}_5\text{F}(\text{PO}_4)_3$, $\text{Ca}_5\text{Cl}(\text{PO}_4)_3$ and $\text{Ca}_3(\text{PO}_4)_2$. It is possible that excess fluorine in the diet causes an increased deposition of CaF_2 in the teeth and possibility of less phosphorus deposition. We expect to analyze these teeth thoroughly to observe the chemical changes brought about. The toxic action of fluorine is very likely due to its precipita-

tion of calcium involving a lowering of the calcium ion concentration, producing first tetany and then death. It is probable that fluorine in the waters from this area may have a more detrimental effect than merely on the teeth. Fluorine is a very active and toxic element. A female rat weighing eighty four grams was injected intraperitoneally with 2 cc. of solution containing eighty mgs. of NaF and died in six minutes time. Another animal whose weight was eighty gms. received 160 mg. NaF intraperitoneally and died in seven minutes. The animals exhibited tetany before death. Other animals behaved likewise. Injection of CaCl_2 before the administration of the fluoride did not prevent tetany and death. For instance as an example a female, weight seventy eight grams, received intraperitoneally two cc. of CaCl_2 containing 120 mgs., which was followed immediately by intraperitoneal injection of two cc. of NaF containing eighty mgs. Death occurred and tetany intervened. The CaCl_2 did prolong the life of the animal since it lived well over two hours. Experiments are now being conducted at Iowa State College to determine how fluorides may be removed from water and the general effects of fluorine on metabolism.

SUMMARY

Mottled enamel has been shown to occur in a certain locality in Iowa. This is the first report of this condition in the State of Iowa.

The mottling of the teeth is due to the presence of excess concentration of fluorides in the water.

Analyses are being made for fluorine in the waters from various sections of the state.

The cause of mottling of the teeth from this area has been verified by experiments on rats.

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