CHAPTER 3

Diatomaceous Earth Pneumoconiosis

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Diatomaceous earth pneumoconiosis is a relatively new industrial pulmonary disease. In order to understand its various aspects, one should be aware of the nature and origin of diatomite deposits.

In the middle Miocene period about five to twenty million years ago, much of what is now the California coastline lay below sea level. The area around the present town of Lompoc, which is about 160 miles north of Los Angeles, may have been an archipelago of low lying islands or a series of lagoons and bays favorably located for the quiet deposition of sediment present in the sea water.

The diatoms which form the greater part of this sediment are single-celled algae or flowerless aquatic plants, occurring in a wide variety of shapes and sizes. They are invisible as units but easily recognizable in colonies as gelatinous growths either free-floating or adhering to rocks and larger vegetation. Because of temperature, food supply and light conditions, the diatoms grew in greatest profusion. In addition, prevailing winds, tides and ocean currents brought to the Lompoc area enormous quantities of these plankton organisms from considerable distances. Unlike most plants the diatom lives within a siliceous cell wall. The complete diatom consists of the organic cell itself and two half-cell walls or valves. These cell walls or shells are composed of opaline silica extracted from sea water, are porous and can be found in many different shapes and sizes. When their life cycle is completed, diatoms pass from organic plant life. Their siliceous cells become an inorganic mineral in the form of sediment on the bottom of the body of water they have inhabited.

As the Miocene period drew to a close, diatom growth in the Lompoc area diminished greatly. Non-diatomaceous sediments were deposited on the ocean floor covering the diatom remains. There were profound changes in the whole area. The ocean floor was elevated, the sea receded, earthquakes and volcanoes changed the whole topography. Thus the beds of fossilized diatoms were gently folded into a

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series of strata alternating with vegetable matter, rock and soil. Time and weather eroded the hills, centuries of rains percolated through the diatom beds and produced the highly purifying effect of many washings.

The diatomaceous earth industry is a comparatively recent one, although the substance has been used in various ways since the days of the Romans. In 1870, Nobel invented dynamite which consisted of diatomaceous earth saturated with nitroglycerin. This invention stimulated the search for further deposits of the mineral, and today mines are established in Germany, France, and Italy, but the largest deposits are found in California.

The physical form of the diatom fossil is its most remarkable characteristic. It already has been mentioned that diatoms are found in various shapes and sizes. Because of the silica content the fossil is extremely strong and is not destroyed in the manufacturing processes. It is impossible to compress diatomaceous earth because the points of contact of the multi-shaped fossils are limited to their outermost points. A mass of diatomite might be likened to a loose mass of thistledown except that compression is impossible. Thus there is great bulking value or low apparent density of the powder (processed diatomite). One cubic foot of diatomite weighs approximately 10 pounds. Because of the porous structure of the fossil shell and the low density of the mass, there is very high absorptive capacity of the finished product. Processed diatomite can absorb three times its own weight of liquid, but peculiarly enough it does not absorb moisture from the air. One other important characteristic is the great surface area of the fossil remains. The total surface area of a pound of processed diatomite may be more than 100,000 square feet. This is important when the processed powder is used to absorb other things such as insecticides or to act as a catalyst carrier.

Diatomaceous earth is used in the filtration of water, in sugar refineries, in the production of beverages, in the pharmaceutical industry, and in the cleansing of petroleum, vegetable, and fish oils for various industrial applications. It is also used as a mineral filler for lacquers and paints, in molded plastics, paper, insecticides, fertilizers, and polishes. It is used as an insulating material in wallboard and pipe-coverings and is especially useful in high temperature insulation for it can withstand temperatures up to 2600 F. better than many other substances. Other uses of diatomite are catalyst carriers, as an admixture for concrete, and as an oil and water absorbent.

Diatomite is mined in open pits or quarries. The over-burden is re-

moved and the crude ore is transported to the mill where it is crushed, screened and milled. The three types of powders which are processed in the milling operation are natural, calcined, and flux-calcined. The crude material is dried at temperatures ranging from 300 to 800 F. The mineral then passes through a process of air separation and classifying and then is ready for shipment. This product is known as a natural powder. Calcined powders pass through the same process except that they are calcined in a temperature range of 1600 to 1800 F. Flux-calcined powders are produced in the same manner and the same temperature range as the calcined powders except that a soda ash flux is added to the process.

The natural powders are composed of amorphous or opaline silica and contain no crystalline silica or quartz. Calcining changes small amounts of this amorphous silica to a crystalline silica in the form of cristobalite. Once again, there is no quartz silica in this product. Flux-calcining changes greater amounts of the amorphous silica to crystalline cristobalite and in addition there are traces of another crystalline silica, tridymite.

It has been noted that the diatomite industry is of very recent origin. It received its first impetus when Nobel invented dynamite in 1870. However, the occupational pulmonary disease associated with this industry was not recognized until Legge and Rosenerantz,[1] in 1932, reported a high incidence of pneumoconiosis due to silica among diatomite workers in California. There have been several other articles in the literature here and in Europe in which there are conflicting reports concerning the effects of inhaled diatomite. The words, diatomaceous earth, kieselguhr, tripolite, infusorial earth, tripoli, fuller's earth and fossil flour have been used synonymously and indiscriminately to designate the same material. Obviously this is incorrect for some of these are earths or clays, others are derived from rock, while diatomite is a particular form of fossil remains. In addition, workers often were exposed to two or more toxic dusts so that no clinical or X-ray pattern could be identified with a specific dust exposure.

In 1948, Vigliani and Mottura[2] made a very significant contribution to our knowledge. They first drew attention to the fact that when crude diatomite was calcined at 1250 C. some of the amorphous silica was changed to crystalline silica in the form of cristobalite. Inhalation of this cristobalite produced a "malignant silicosis" not seen in the crude diatomite workers. These observations were confirmed in the U.S. Public Health Service report[3] on their 1953–54 survey of the American diatomite industry.

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Diatoms exist in both salt and fresh water, and there is very little difference in the industrial applications of these two types. In 1952, Smart and Anderson[1] reported some apparent differences in the X-ray findings in workers exposed to marine diatomite, when compared with those exposed to the limnetic type. However, in a later survey of the diatomite industry the U.S. Public Health Service[2] reported that the source of crude diatomite, whether of salt or fresh water origin, did not appear to influence the per cent of cristobalite found in the finished products. Thus it would seem that if cristobalite is the causative agent of disabling pulmonary disease in diatomite workers, no conclusions are warranted as to a difference in the biological reaction of diatomite based on its source of origin.

The chief clinical symptom and the prime cause of disability in diatomite pneumoconiosis is dyspnoea. There is no correlation between the degree of dyspnoea and the extent of fibrosis seen on the X-ray. As one might expect with cases of industrial pulmonary disease, there can be varying degrees of cough, anorexia and weight loss. Auscultation of the chest can elicit altered breath sounds and rales or wheezes, but there is no single sign which is pathognomonic of the disease. It is interesting to note that clubbing of the fingers is not seen. In addition, the incidence of intercurrent pulmonary infections such as acute bronchitis and pneumonia is not significantly increased among those with diatomite pulmonary fibrosis.

For many years there has been an accepted feeling that inhalation of crystalline silica in the form of quartz predisposed [illegible] development of pulmonary [illegible] and tuberculosis [illegible]. The reason for this difference in the relationship between crystalline silicas and pulmonary tuberculosis is obscure.

Pulmonary function tests on workers who have only minimal X-ray changes show no consistent pattern of dysfunction. Those with X-ray evidence of coalescent disease may have a marked lowering of their maximum breathing capacities.

The characteristic X-ray patterns associated with this disease have been described as linear, nodular, or coalescent. The linear pattern appears to be simply an exaggeration of the bronch-vascular pattern or a fine lace-like network appearing prominently in all lung fields. The early nodular pattern can be described as very fine nodulation, homogeneous in character, resembling the granular pattern of ground glass. The coarser nodulation appearing later in the disease is

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Fig. 1. Diatomite Pneumoconiosis. Linear and nodular patterns with early coalescence in both apices.



Fig. 2. Diatomite Pn
taken for cavitation

somewhat similar to that seen in simple silicosis. The coalescent or confluent patterns exhibit progressively larger coalescent masses usually in the apices.

There often is seen a marked emphysema with small emphysematous blebs or larger bullae. These sometimes rupture and different degrees of spontaneous pneumothorax are seen. The various linear, nodular, and coalescent patterns have been described as appearing in first, second, and third degree stages, but there is no constant progression from one stage to the other as in the regular stages of

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Fig. 2. Diatomite Pneumoconiosis. Apical emphysematous bullae, sometimes mistaken for cavitation of tuberculosis.

asbestosis or silicosis. There also can be various combinations of these different patterns seen in one film. For instance, it would be possible to have a first stage nodular pattern established in association with early coalescent lesions before the second and third stages of nodulation appear.

There is no consistent X-ray pattern which can be correlated with the occupational exposure of an individual. Some people work for many years with a potential exposure and develop no disease. Others may work for a short time in cristobalite-bearing powders and de-

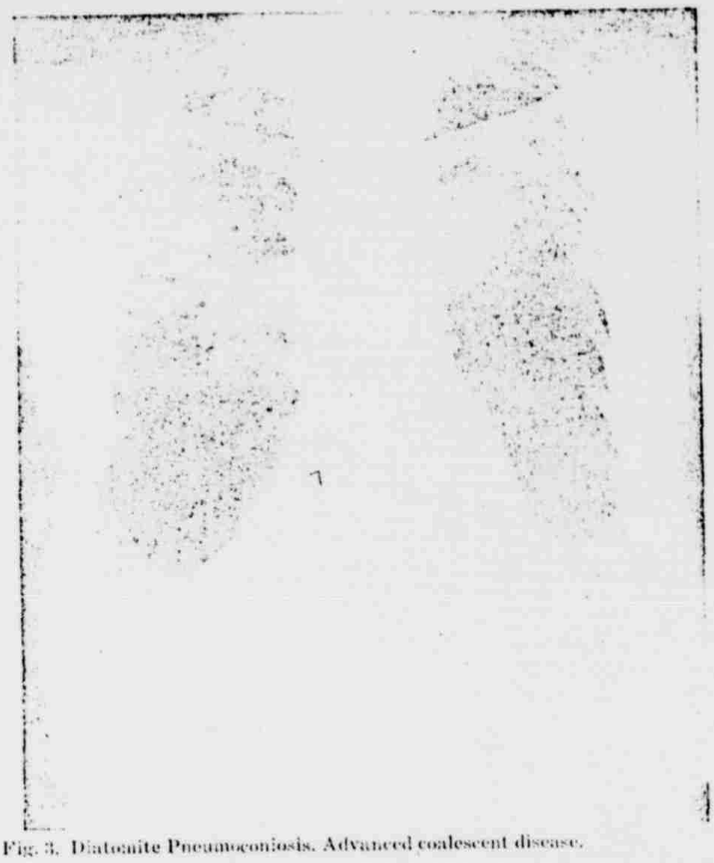


Fig. 3. Diatomite Pneumoconiosis. Advanced coalescent disease.

velop early coalescent lesions with accompanying dyspnoea. The coalescent lesions develop only in those who have been exposed to the calcined or flux-calcined powders which contain cristobalite. Coalescence never appears in those whose exposure was limited to the natural powders containing *only amorphous silica*. Some cases work for as long as 30 years in natural powder exposure and show *only minimal* granular exaggerations on their X-ray.

A few rare cases have been noted who started to work with normal X-ray films, had a potential exposure to minimal quantities of cristobalite-bearing powder and after working for a period of several

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months these cases left their employment. Several years later a casual chest X-ray showed that they had developed typical coalescent lesions, and one case died from diatomite pneumoconiosis eleven years after his last exposure.

The exact cause of the coalescent lesion itself is unknown. It may result from the action of cristobalite itself, or it might be due to an infectious process, or a type of immunology tissue response. It might be caused by temporary inhalations of massive amounts of diatomite, such as might occur in processing equipment breakdown, resulting in a severe overloading of the lymphatic system. Some have believed that tuberculosis has been the cause of this lesion. However, tuberculin skin testing of employees over several years at one California plant has shown that 65 per cent of those with coalescent X-ray shadows have had negative skin tests and only 35 per cent were positive. In addition, pathological investigation of the coalescent lesions seldom revealed the typical landmarks of tuberculous infection.

There is no cure, in the sense of restitution to integrity, for an established case of this pneumoconiosis. Removal from further exposure to dust obviously is the first consideration. This then should be followed by supportive and palliative treatment for intercurrent conditions as they arise.

Prevention of any dust exposure in the first place is the only way to control development of the disease. Ventilation of dust at its point of origin, proper work methods to avoid atmospheric contamination and diligent housekeeping are necessary. For industrial hygiene purposes the maximum allowable concentration for cristobalite-bearing materials is set at 5 million particles per cubic foot, and the maximum allowable concentration for noncristobalite-bearing, or natural earth powders is set at 20 million particles per cubic foot. Employees' exposures which do not exceed the maximum allowable concentration during a regular eight-hour working day should develop no pulmonary disease.

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