

FILE NAME: Concrete (CONC)

DATE: 1949 Nov

DOC#: CONC020

DOCUMENT DESCRIPTION: Journal Article - [Silicosis] A New Approach to Pneumoconiosis



ROCK PRODUCTS



NOVEMBER, 1949

THE INDUSTRY'S RECOGNIZED AUTHORITY

VOL. 52, No. 11

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ROCK PRODUCTS is published monthly by MACLEAN-HUNTER Publishing Corporation, 309 West Jackson Blvd., Chicago 6, Illinois; Horace T. Hunter, President; E. R. Gauley, Vice President; J. L. Frazier, Secretary. Copyright, 1949. Entered as second-class matter, Jan. 30, 1936, at the Chicago, Ill. post office under the act of Mar. 3, 1879. Additional entry at Milwaukee, Wis. ROCK PRODUCTS is indexed regularly by Engineering Index, Inc.

SUBSCRIPTION INFORMATION

Subscription Price. United States and Possessions, Canada one year, \$2.00; two years, \$3.00; three years, \$4.00. Pan American, one year, \$4.00; two years, \$7.00; three years, \$10.00. All other foreign, one year, \$6.00; two years, \$12.00; three years, \$15.00. Twenty-five cents for single copies. Indexed in the Industrial Arts Index. Canadian subscriptions and remittances may be sent in Canadian funds to ROCK PRODUCTS, P. O. Box 100, Terminal "A," Toronto, Canada.

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Silicosis

A New Approach to Pneumoconiosis

Research at Marquette University indicates a direct relationship between formation of fibrosis and electrical properties of dusts

RESearch now being carried on at the Marquette University School of Medicine in Milwaukee, Wis., is giving new insight into the basic mechanism of pneumoconiosis, the strange, tuberculosis-like disease affecting workers who breathe air laden with certain types of mineral dusts. Results of vital interest to the rock products industry may develop from this work.

The disease has been known for years, but for a long time it was believed to be due only to dusts of minerals containing silicon, and was called "silicosis." In recent years the list of mineral dusts known to be capable of causing the disease has grown to include such minerals as wulfenite and berlinite, which do not contain silicon, so that the more general name "pneumoconiosis" has been adopted. Pneumoconiosis is characterized by the growth of fibrous tissue in the lungs, and dusts which cause it are said to be "fibrogenic." Depending on its extent, the growth may impair the functioning of the lungs to a sufficient extent to cause death directly, or it may have a weakening effect which paves the way for tuberculosis, pneumonia, or other respiratory diseases.

There have been several theories about what makes dusts fibrogenic. An early belief was that the sharp edges of dust particles irritated the lung tissues, but this has been discarded by most investigators because it has been impossible for them to show any definite relationship between the sharpness of particle edges and the ability of the particles to cause a fibrotic reaction in the lungs. Silicon carbide, for example, has been tested, and is not fibrogenic.

New Theories

The theory accepted by many investigators today holds that fibrogenic dusts dissolve slowly in the lung tissue fluids, forming a toxic solution. This theory was lent strength in the days when only silicosis was known, by the fact that injections of colloidal silica into the bloodstream of laboratory animals was usually fatal. However, the slow solubility theory now known about pneumoconiosis, and certain experiments which have been performed to test the theory directly seem to give results which indicate that it is definitely not true. Delicate analyses of the blood of animals which have died of pneumoconiosis, for instance, do

By GEORGE ELWERS*

not show in the blood any more than normal amounts of the chemical elements of the dusts which caused the disease in the animals.

Searching for a common denominator of all dusts which are fibrogenic, Drs. Silas Evans, Walter Zeit, and their associates at Marquette have found evidence that there is a direct relationship between the ability of a dust to cause a fibrotic reaction in tissue and certain electrical characteristics of the dust crystals. Specifically, it seems that only dusts which exhibit the piezoelectric effect are fibrogenic.

Piezoelectric Effect

The piezoelectric effect may be described as the ability of certain crystals, under proper conditions, to effect an interchange between mechanical and electrical energy. A common example of its use is in the electric phonograph, where the mechanical vibrations of a needle following the record grooves are transformed into electrical impulses by a crystal. This property is found only in crystals which are poor conductors of electricity, and which are non-centro-symmetrical—that is, which have an unbalanced, off-center arrangement of atoms in the crystal.

If only crystals which exhibit the piezoelectric effect are capable of causing pneumoconiosis, then it would seem logical to conclude that the piezoelectric effect itself is in some way the cause of the fibrous growth of pneumoconiosis. The experimental evidence obtained so far indicates that this is true. So far, the great majority of insoluble piezoelectric minerals which have been tested have been found to be fibrogenic, and no minerals which are non-crystalline or which have symmetrical crystals have been proven to be fibrogenic. Quartz, for example, is a well-known piezoelectric mineral. It has also been long known as a mineral which causes silicosis. But fused quartz, which is amorphous and so has no crystalline structure, has been shown to be non-fibrogenic. Chalcopyrite also has been tested, and does not produce pneumoconiosis. It does have an asymmetrical crystal, but it is a good enough conductor of electricity so that it does not exhibit the piezoelectric effect.

Likewise, many other minerals have been tested, and most give results which would be expected according to the theory.

Certain minerals have been found which do not have piezoelectric properties, yet cause a fibrotic reaction in laboratory animals. Aluminum phosphate and asbestos are examples. A possible explanation of these seeming discrepancies is that these minerals undergo chemical changes while in the lungs which convert their physical structure into piezoelectric crystals. This hypothesis is being actively investigated in current experiments.

Since involved questions of physical structure and physical properties of matter have arisen in these experiments, the Marquette scientists have called in outside experts to aid them in their work. The Allis-Chalmers Manufacturing Co. has played an important role, rendering active assistance through E. H. Brown, director, and Jack T. Wilson, William Allis, and Richard Graham, physicists, and other members of its Engineering Development Division. The company has also contributed funds and certain specially designed and constructed equipment. Dr. Harry Ihrig, physical chemist of the Globe Steel Tube Co., has contributed advice and assistance on X-ray diffraction and spectrographic analyses, and scientists of the Bell Telephone Laboratories and the University of Minnesota also have contributed technical advice and services.

It is difficult to assess fully at this time the possible value of these experiments to the rock products industry. Certainly it seems possible to predict when a mineral will be capable of causing pneumoconiosis, which will be valuable to the operator of a mine, quarry, or processing plant in determining the extent of dust-control and other protective measures which he needs to take. In cases of pyro-processing of minerals where crystalline structure may be altered, it can be determined at what point in the process the mineral becomes or ceases to be dangerous, suggesting the possibility of altering the process to prevent production of a dangerous dust or to convert a dangerous dust into a benign one. And finally, as science draws closer to understanding the basic causes of pneumoconiosis, the discovery of better preventative and curative measures is made more possible.

*Allis-Chalmers Mfg. Co., Milwaukee, Wis.