PREVALENCE OF CLINICAL AND RADIOGRAPHIC ABNORMALITIES IN 150 WORKERS EXPOSED TO NON-CALCINED DIATOMACEOUS EARTH IN CENTRAL CALIFORNIA

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INTRODUCTION

Diatomaceous earth, or diatomite, is a siliceous sedimentary rock composed essentially of the skeletal remains of microscopic single-celled aquatic plants called diatoms. Diatomite is a valuable material with a range of industrial uses. World production is approximately 1.6 million short tons, 45% of which is from the United States. California accounts for more than half of United States production.[1]

Diatomite consists primarily of an amorphous silica containing a small percentage of crystalline silica detectable by conventional X-ray diffraction analysis. In the past, diatomite processing included calcination which involves heating the natural diatomite to high temperatures, with or without an alkaline flux, thereby converting the amorphous silica into a fibrogenic crystalline form called cristobalite. The cristobalite content of natural (uncalcined) diatomite in typically less than 1%; that of straight-calcined 10-20%; and that of flux-calcined products 40-60%.

Pneumoconiosis in the diatomite industry has been associated with exposure to calcined products containing cristobalite. In 1953, a United States Public Health Service survey in California demonstrated a 25% prevalence rate of pneumoconiosis among diatomite workers who had been employed for five years or more.[2]

Since that time, dust control measures have been instituted throughout the diatomite industry and calcination of the natural diatomite has largely been eliminated. Subsequent surveys of the diatomite industry have demonstrated the effectiveness of dust control measures.[3]

In 1983, a medical surveillance program was begun at Excel Mineral Company, which processes sedimentary rock (characterized as diatomaceous earth) into cat litter absorbent. This report summarizes data on the respiratory symptoms, pulmonary function studies and chest roentgenograms of 150 employees with at least five years of continuous employment at Excel Mineral Company.

SUBJECTS AND METHODS

Study Population

Excel Mineral Company is located in the southern San Joaquin Valley of California and operates two plants at Taft and McKittrick. All current employees at both plants participated in two medical surveillance surveys done by the Southern Occupational Health Center of the University of California at Irvine. Only employees with at least five years of continuous employment at Excel were included in this report.

Exposure Index

Since only scant personal monitoring data existed on the level of past dust exposure, an exposure index (E.I.) was constructed. First, employee tasks were subdivided into eight categories: (1) mining; (2) milling; (3) packaging; (4) loading dock; (5) delivery; (6) administration; (7) maintenance (inside plant); (8) maintenance (outside plant). Next, these eight job categories were divided into "dusty" 1, 2, 3, 7 and "non-dusty" 4, 5, 6, 8 jobs based on the results of a 1977 personal hygiene study. A dusty job was one in which dust concentrations exceeded 10 mg/cc[3]. A year spent at a dusty job prior to 1971 (when dust controls were nonexistent) was counted as the equivalent of two dust-years of exposure after 1971. A year spent in a non-dusty job either before or after 1971 did not contribute to the exposure index. Therefore, the E.I. represents the sum of twice a pre-1971 dust-year plus a post-1971 dust-year.

Study Protocol

All current employees participated in medical surveillance surveys done in 1983 and 1988 which included a self-administered health history questionnaire, pulmonary function studies and chest roentgenograms.

The questionnaire elicited information about general medical conditions, specific respiratory system complaints and a complete occupational history. The presence of any one of the following respiratory complaints of cough, wheezing, chest tightness and dyspnea was included in calculation of a total respiratory symptom score. The symptom score ranged from zero (no symptoms present) to four (all four symptoms present).

Spirometric pulmonary function studies were done on site and consisted of a forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1). Spirometry was performed by a NIOSH-trained technologist on an 8-L Collins portable recording spirometer (Warren E. Collins, Braintree, MA) which met NIOSH apparatus criteria. Predicted values were based on Knudson's regression equations.[4]

A single posteroanterior chest roentgenogram was obtained at a nearby physician's office and was interpreted blindly by one of the authors (ENS) according to the ILO Classification of the Pneumoconioses (1980).[5]

Mineral Analysis

Ore from the opencast mine was sent to Clayton Environmental Consultants, Inc. (Southfield, Michigan) for complete mineral content analysis. In addition, dust from several areas in both plants was sent for microscopic particle sizing and mineral analysis including a determination of the proportional content of amorphous and crystalline silica (alpha-quartz, cristobalite and tridymite).

Statistical Analysis

Comparisons between exposure groups were done with Student's two-tailed, chi-square test with and without Yates' continuity correction, and Fisher's exact test.

RESULTS

One hundred fifty (121 males and 29 females) employees present for the 1983 survey who were continuously employed at Excel and present for the 1988 survey were included in this analysis. All subjects were subdivided into three approximately equal categories based on exposure index. Group I (n=82) had an E.I. of zero to eight years, Group II (n=47) had an E.I. of nine to sixteen years, and Group III (n=21) had an E.I. of seventeen or more years. All three groups were comparable ($P > .13$) in sex, age, race, and tobacco smoking history.

Respiratory Symptoms

Respiratory symptom scores increased with exposure index. Group I had a symptom score of 0.8, Group II 1.0 and Group III 1.4. ($P = .048$) In all three Groups, a large proportion of employees complained of wheezing (Group I 26%, Group II 23% and Group III 43%).

Pulmonary Function Tests

Spirometry revealed no obstructive or restrictive defects. Group I had an FVC of 90.6%, and FEV_1 of 78.9% of predicted. Group II had an FVC of 88.0%, and FEV_1 of 79.8% of predicted. Group III had an FVC of 87.9%, and FEV_1 of 79.1% of predicted. There was no significant difference in pulmonary function among the three groups.

Roentgenographic Findings

Eleven employees (7%) had chest roentgenograms which demonstrated parenchymal abnormalities of doubtful significance for pneumoconiosis (profusion score of 0/1 or 1/0). Three employees (2%) had parenchymal abnormalities on chest roentgenograms consistent with pneumoconiosis (profusion score of 1/1 or greater).

Of the three employees with films consistent with pneumoconiosis, one employee's film in Group II had a profusion score of 2/1 and two employees' films in Group III had scores of 2/1 and 2/2. Of note, the three employees whose films demonstrated pneumoconiosis were employed for a total of 9, 20, 21 years, respectively. There were no parenchymal abnormalites suggestive of irregular or large opacities. In addition, no pleural findings were seen.

Mineral Analysis

Microscopic sizing of dust samples taken from the mill area at both plants revealed a respirable dust content (two microns or less) of 91% of particles. Mineral analysis by X-ray diffraction of both ore and dust samples revealed a mean proportional silica content of 75%, chiefly in the form of amorphous silica (mean 69%) and crystalline silica (mean 6%). Crystalline silica was present in two forms: alpha-quartz (mean 2%) and cristobalite (mean 4%). The mineral content of ore and area dust samples did not differ appreciably.

DISCUSSION

In the past, the prevalence rate of pneumoconiosis in the diatomite industry in California was 25%. Recent surveys of employees in the California diatomite industry have demonstrated a steadily decreasing pneumoconiosis prevalence rate. In fact, a survey in 1984 revealed that only 6 employees out of 473 (2.3%) had films which were classified 1/2 or higher and these employees had been employed in diatomite processing for more than 25 years.[3]

In our survey, we expected to find an even lower pneumoconiosis prevalence rate than previously published surveys for several reasons. First, calcining at Excel antedated the employment of nearly all members of the current workforce. Second, control measures at Excel have reflected the industry standard for a number of years. Third, we expected that mineral analysis of the natural, uncalcined diatomite would yield a crystalline silica content lower than the 6% mean figure obtained.

In our survey, we found a pneumoconiosis prevalence rate (2%), which was slightly less than previous surveys. Of concern, however, is the fact that employees with positive films had worked in the diatomite industry for much shorter periods of time than those employees with positive films described in other studies.

Mineral analysis of the ore and dust may provide some explanation for the pneumoconiosis prevalence rate found. Since the content of fibrogenic crystalline silica seen in the Excel ore and dust exceeds what is generally found in uncalcined diatomite, employees at Excel may be at greater risk than other employees in the diatomite industry. Further study of this population is planned.

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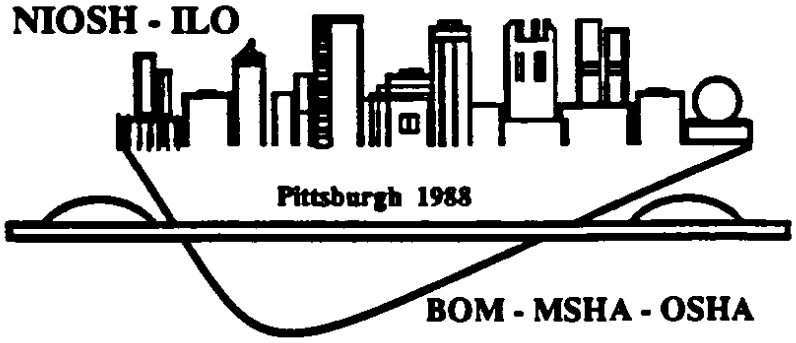

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