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Pneumoconiosis and quartz content of respirable dusts in the coal mines in Zonguldak, Turkey

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ABSTRACT

Coal Worker's Pneumoconiosis (CWP) is one of the most important occupational health problems in Turkish coal mining. Despite the decrease in employment and production at Turkish Hardcoal Enterprise (TTK) in the Zonguldak Basin, the occurrence of pneumoconiosis is still very high, particularly among the face workers. This study aims to evaluate the dust concentrations and quartz contents of respirable dusts in coal faces and pneumoconiosis risks related to face workers in TTK collieries. The mean respirable dust exposure experienced by the face workers was evaluated and compared with the occupational exposure limits. The data on the dust samples exhibit great variations. The quartz contents of respirable dusts were determined by a FTIR spectrophotometer. The mean respirable dust concentration in the coal faces varies from 1.6 to 14.5 mg/m^3 while the quartz content varies from 0.7 to 10.4%. The mean respirable dust concentrations in the coal faces in Karadon, Amasra, Armutcuk and Kozlu collieries are above the TLV (5 mg/m^3) of Turkey and the percentage of the measurements exceeding the TLV in the coal faces range from 25% to 100. An analysis of variance was performed to investigate the effects of workplace and seam characteristics on respirable dust levels. According to the results of variance analysis (ANOVA), it was seen that there are significant differences between seams and collieries in terms of dust concentration and quartz contents of respirable dust.

CWP is still the most important problem in the collieries of TTK. The occurrence of CWP is higher among underground face workers. There have been 200 CWP cases in the last decade with a prevalence rate of 6.3%. CWP rates in the coal faces of the collieries increase as the respirable dust levels and quartz contents increase in general. This finding indicates that the TLV (5 mg/m^3) of Turkey should be re-evaluated and additional safety precautions should be taken in the workplaces where high quartz contents of respirable dust exist.

1. Introduction

Coal Workers' Pneumoconiosis (CWP) is a lung disease that results from breathing in coal dust over a long period of time. Several factors increase a person's risk of developing pneumoconiosis such as the concentration of respirable coal dust, coal dust particle size and its composition, free silica content (quartz minerals), the duration of exposure, age, work environment and work practices of workers (Antao et al., 2005; Attfield et al., 2007; Kenny et al., 2002; McCunney et al., 2009; Stoces and Jung, 1962). Relevant studies in the literature have shown that the prevalence of CWP is primarily determined by both the composition of respirable dust (coal rank, volatile content and free silica content-quartz minerals) and the exposure factors such as dust concentration and the duration of exposure (Attfield and Morring, 1992; Niu, 1996; Walton et al., 1977).

A study carried out in West Germany by Reisner and Robock (1977) showed considerable differences in the risk of simple pneumoconiosis with exposure to similar mass-concentrations of dust. Where the mineral content of coal was comparable, more pneumoconiosis occurred in collieries mining higher-rank coal and cytotoxicity. These studies indicated that the damage caused by respirable dust increased with geological age and with a higher rank of seams. High-rank coal is that which is relatively smokeless and free from bitumen and includes anthracite, steam coal and high-grade coking coal. The higher the rank, the higher the carbon content of the coal. The quartz content of airborne dust is possibly low when high-rank coal is mined and higher in low-rank coalfields (Walton et al., 1977).

Coal typically contains substantial amounts of mineral matter, of which quartz is an important component. Other constituents related to pneumoconiosis in mixed respirable dust are kaolin, mica, coal rank and ash. The major exposures to coal dust occur during mining and processing of coal as well as during the implementation of ground control works and drilling for explorations and blasting (IARC, 1997). The content of respirable mine dusts observed in coal

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Table 1
Workplace risk classification in accordance with threshold limit values in the Turkish dust regulation (MLSS, 1990).

Dust risk degrees	TLV Respirable mine dust containing quartz (mg/m^3)	TLV Respirable quartz dust (mg/m^3)
I	0–2.5	0–0.125
II	2.6–5	0.130–0.25
III	5.1–10	0.27–0.50
IV	>10	0.5

TLV: Threshold Limit Value.

mining varies depending on many factors such as the formation of coal seam, specific structure of the seam, adjacent rock strata and the mining methods being applied.

The main sources of quartz minerals in respirable dust are silica minerals (quartz, cristobalite, tridymite), and silicate minerals as in rock fragments, feldspar minerals and clay minerals (Stoces and Jung, 1962).

Several studies have been carried out in USA, UK, and other European countries on dust exposure limits in order to mitigate, if possible to eliminate, the health effects of exposure to dust. These exposure limits provide the necessary guidance for planning, engineering monitoring and controlling the systems and work practices for effective dust control. However, there has not yet been an attempt to establish a uniform international system for setting the limit values for workplaces. There are wide variations in the dust exposure limits of major countries and regulatory authorities. Moreover, there is even no common definition of the limit values or the safety level with respect to occupational exposure. Setting the limit values is usually based on the dust dose, duration of exposure and incidence of pneumoconiosis by many countries. In practice, the limit values are implemented mostly on the basis of a compromise between the health requirements and the technical possibility of satisfying them (Maciejewska, 2008).

Currently, the dust exposure limits applied by major coal-producing countries are based on coal dust alone (e.g., 3.8 mg/m^3 in the United Kingdom, 5 mg/m^3 in Australia and Canada) or on a mixture of coal and quartz minerals as in the United States (2 mg/m^3 when the percentage of quartz is 5 or less, or (10 mg/m^3)/per cent SiO_2), or in Germany (4 mg/m^3 when the per cent quartz is 5 or less. or 0.15 mg/m^3 otherwise), or on pure quartz (e.g. Poland, with a 0.05 mg/m^3 limit) (Maciejewska, 2008).

In Turkey, CWP was first recognized as a problem in the early 1960s. Starting from 1977, workplace respirable dust level monitoring was initiated in Zonguldak hardcoal basin. In 1990, the first regulation related to dust control "dust control and prevention guidelines in mining, quarry and tunneling" was issued in Turkey. In this guideline, dust limit value in collieries is defined by the term "Threshold Limit Value (TLV)". The TLV for respirable coal mine dust is limited to 5.0 mg/m^3 for the quartz minerals providing that its content is less than 5%. If the quartz mineral content is more than 5%, then the TLV (mg/m^3) is calculated from the ratio of 25 to the percentage of quartz minerals in the content of respirable dust (MLSS, 1990).

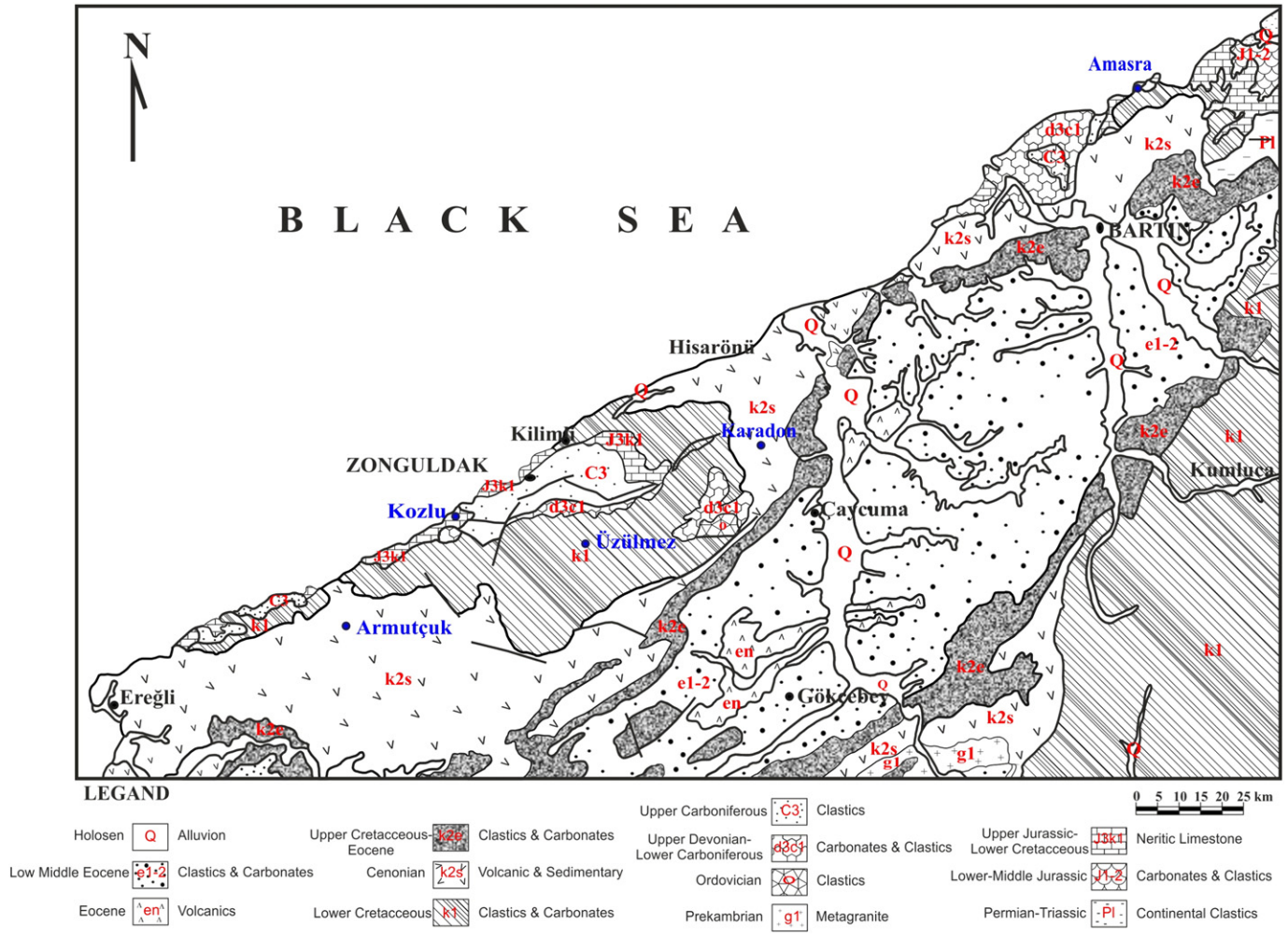

Fig. 1. Geological map of Zonguldak Coal Mines (Buzkan, 2008).