A RESPIRABLE DUST SURVEY OF VARIOUS METALLIFEROUS MINE SITES IN QUEENSLAND, AUSTRALIA

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INTRODUCTION

This paper describes the current development of dust surveillance and respirable quartz monitoring in a range of metalliferous mines in Queensland, Australia. Gold mines and quarries are predominant in the study, although sand, nickel, limestone and bauxite mines are also covered. A Fourier Transform Infra-Red (FTIR) method was developed to measure quartz content in respirable dust samples. The matrix difficulties which are present with such a wide range of sample sources have been overcome using a specific interferent reduction program applicable to any type of material.

BACKGROUND

This program of mine surveillance began as recently as 1986 when the Safety in Mines Testing and Research Station (SIMTARS) was established to provide, amongst other things, an occupational hygiene service encompassing all types of Queensland mining operations. SIMTARS is also involved in electrical and flameproof testing of equipment destined for use in underground coal mining and other potentially hazardous areas. From its extensive, special gas analysis service, SIMTARS also provides an emergency gas analysis service for coal mines in event of a mine disaster.

While the workers in Queensland coal mines are sampled on a regular basis for respirable dust and quartz by officers attached to the Coal Mines Inspectorate (GRANTHAM and BELL, 1987), no regular systematic respirable dust sampling has ever been carried out at Queensland metalliferous mines. The reasons for this include the diversity of mining types and the geographical separation of mine sites in a very large state. Furthermore, many of the mining operations are small and employ few personnel, limiting the feasibility to survey these small mining operations in the past.

In the absence of any data on these mines, the opening gambit was to visit only the major sites to cover the largest concentration of workers and processes, with a few smaller sites included to determine if size affected dust exposure or dust control in any way. From these data, a suitable inspection frequency could be determined and immediate problem areas could be targetted for investigation and improvement. In the longer term, the information can be used in an epidemiological review of dust disease amongst these mining populations.

In addition to the respirable dust monitoring, noise measurements were also made. Collection and processing of the samples was undertaken by the small (5 member) hygiene group. The sampling technique, adapted where necessary to meet the commitments of mining schedules, has followed the Australian Standard 2985 1987 (Workplace Atmospheres—Method for Sampling and Gravimetric Determination of Respirable Dust), itself based on the familiar MDHS 14 of the UK Health and Safety Executive.

METHODOLOGY

Respirable dust measurements were carried out using Dupont P2500 sampling pumps entrained with Casella 37 mm cyclone elutriators. The dust samples collected were analysed for free silica using a Fourier Transform Infrared technique which utilizes computer controlled spectral subtraction of interfering minerals.

Previous techniques in respirable quartz analysis of dust samples containing interfering substances required computer subtraction of known interferents from the sample mixture. Dust samples obtained from mining environments often have interfering minerals which are difficult or impractical to analyse. Using computer software available with modern FTIR's (e.g. Perkin Elmer Model 1750), quartz in mixtures can be readily evaluated without knowing the exact nature of interfering substances. By spectrally subtracting pure quartz (Australian Standard 9950) from the sample mixture a spectrum of the interferent is generated. This interferent spectrum can then be subtracted from the mixture leaving a spectrum of quartz free from interference (see Figure 1). Viability of the resulting quartz spectrum can be determined by either the ratio of the peak heights in the doublet and/or the ratio of the peak heights in the doublet to the minor 690 cm^{-1} peak. While this interference free quartz spectrum can be quantitated using presently accepted methods (e.g. standard regression line and peak heights), it is not necessary since a user generated normalization factor can be used to calculate the quartz content directly. The theory is described briefly below.

Both the mixture and the pure quartz spectra are converted to absorbance. The difference between ordinate values of the two spectra at each data point is determined. These ordinate difference values represent the interferent spectrum and can be represented by

$$d_3 = d_1 - (d_2 \times f)$$

Where d_3 = ordinate values of the difference spectrum or in this case the interfering components of the mixture.

d_1 = ordinate values of the mixture.

d_2 = ordinate values of the pure quartz

f = normalization factor applied to the quartz std. spectrum to make it equal to the quartz component of the mixture.

When the quartz standard spectrum is subtracted from the mixture spectrum, only the interferent spectrum should remain. The true normalization factor is selected interactively by manipulating the difference (i.e. interferent) spectrum. The factor is correctly selected when all contributions from the quartz in the interferent spectrum are reduced to zero. In other words the standard quartz absorbance values are made the same as the absorbance contributed by quartz from the sample mixture. The content of quartz can be readily calculated by multiplying the known weight of quartz in the standard (Wq) by the normalization factor, f: This is

Amount of quartz in mixture = Wq × f

Validation of this method is currently in progress and involves evaluating known percentages of quartz in mixtures prepared at SIMTARS followed by interlaboratory testing of standard samples.

DISCUSSION

All the dust data obtained was incorporated in a data base constructed specifically for this purpose. The results are presented in Tables I—VII. Almost 700 personal respirable dust samples were taken over a 14 month period and of those some 150 were analyzed for respirable quartz content. A significant number of mine types (limestone, nickel, bentonite etc) did not have a quartz problem and are not represented in the quartz histograms.

The present Threshold Limit Value (TLV) for respirable quartz is 0.2 mg/m^3 (although it will soon be lowered to 0.1 mg/m^3). This TLV is an Australian variation of the current ACGIH levels and results from a recommendation made by the National Health and Medical Research Council (NH & MRC, 1978). Epidemiological evidence in the Australian context has not yet been able to establilsh the validity of the NH&MRC recommended levels. Histogram representations of the data indicate that approximately 20% of occupations surveyed fail the respirable quartz TLV of 0.2 mg/m^3 while over 60% will fail when the level is lowered to 0.1 mg/m^3.

The situation with quarries and gold mines is generally worse with the figures being 40%/90% and 30%/50% respectively. In practice there is concern since in 92% of the personnel

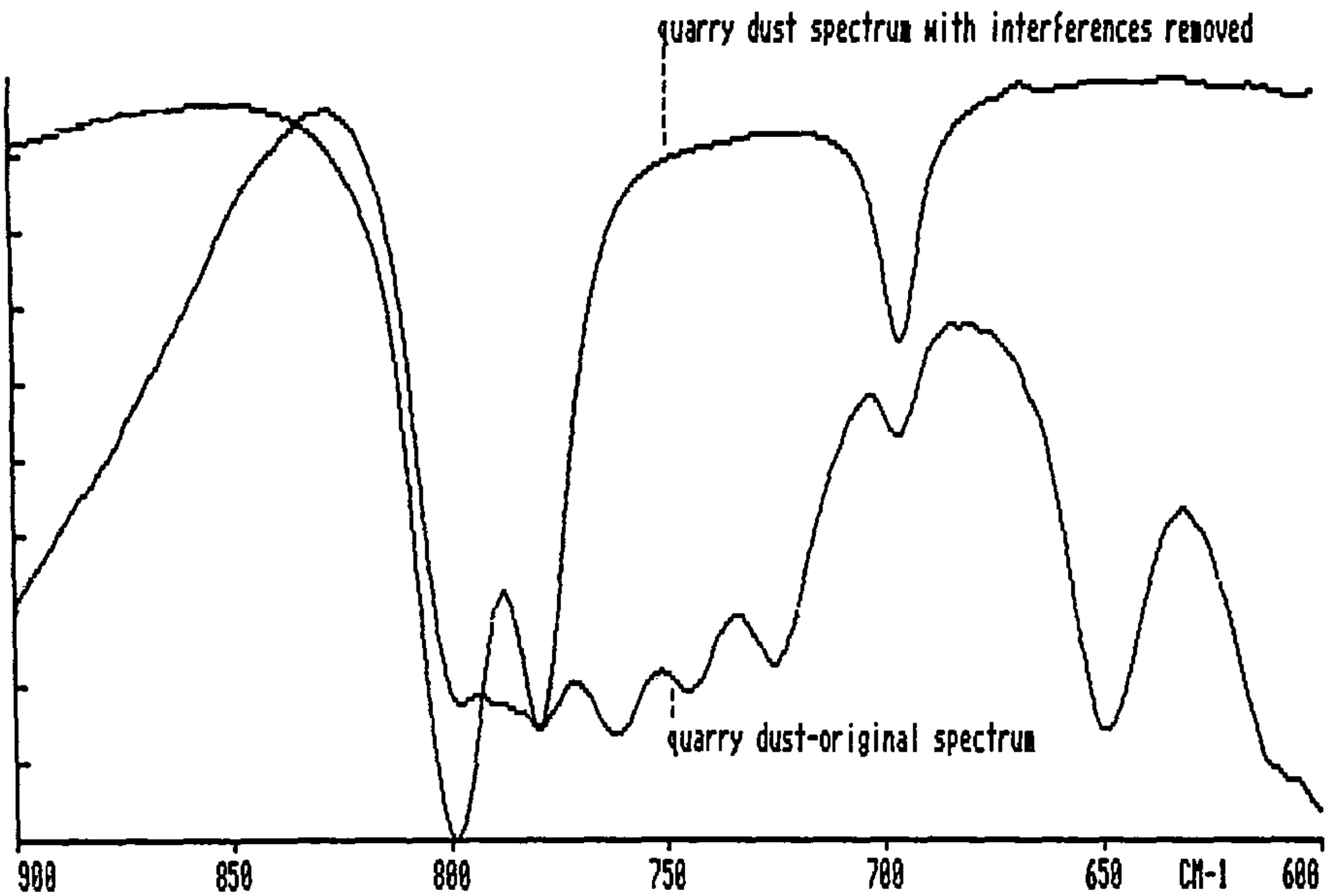
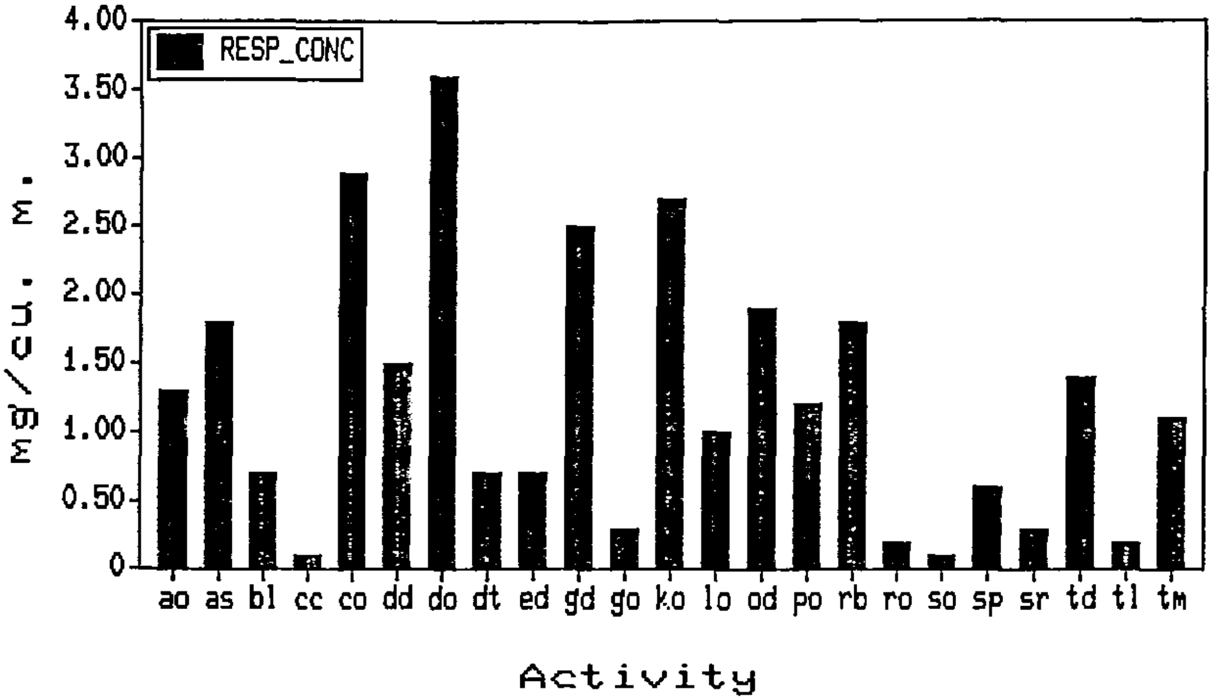


Figure 1.

Table I

Average Respirable Dust Concentration by Activity
(All Metalliferous Mines Surveyed)



ao - Agglomerator Op
dd - Dozer Driver
go - General Operator
rb - Rock Breaker
td - Truck Driver
as - Assayer/Sampler
do - Dragline Operator
ko - Kiln Operator
ro - Roller Operator
tl - Train Loader
bl - Blaster
dt - Dump Truck Driver
lo - Loader Oper.
so - Saw Operator
tm - Tradesman
cc - Conveyor Attendant
ed - Excavator Driver
od - Overburden Driller
sp - Spotter
co - Crusher Operator
gd - General Duties
po - Plant Operator
sr - Scraper Operator

Table II

Average Free Silica Concentration by Activity
(All Metalliferous Mines Surveyed)

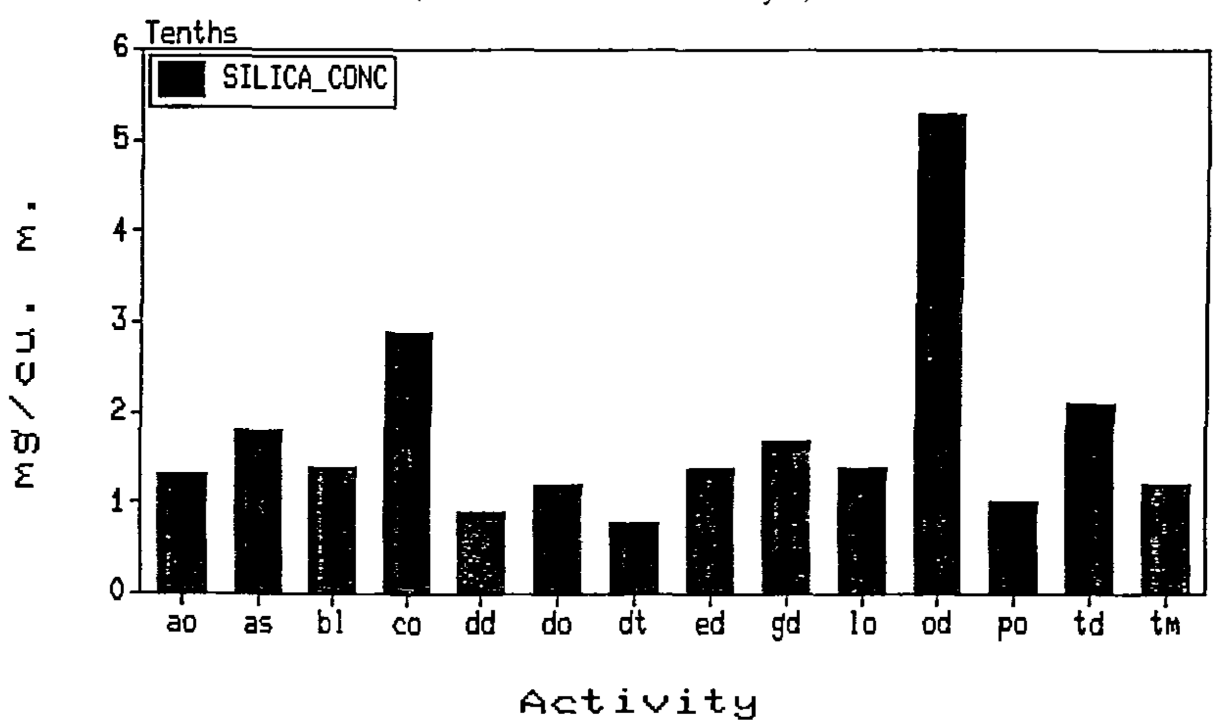


Table III
Average Respirable Dust Concentration by Activity
(All Gold Mines Surveyed)

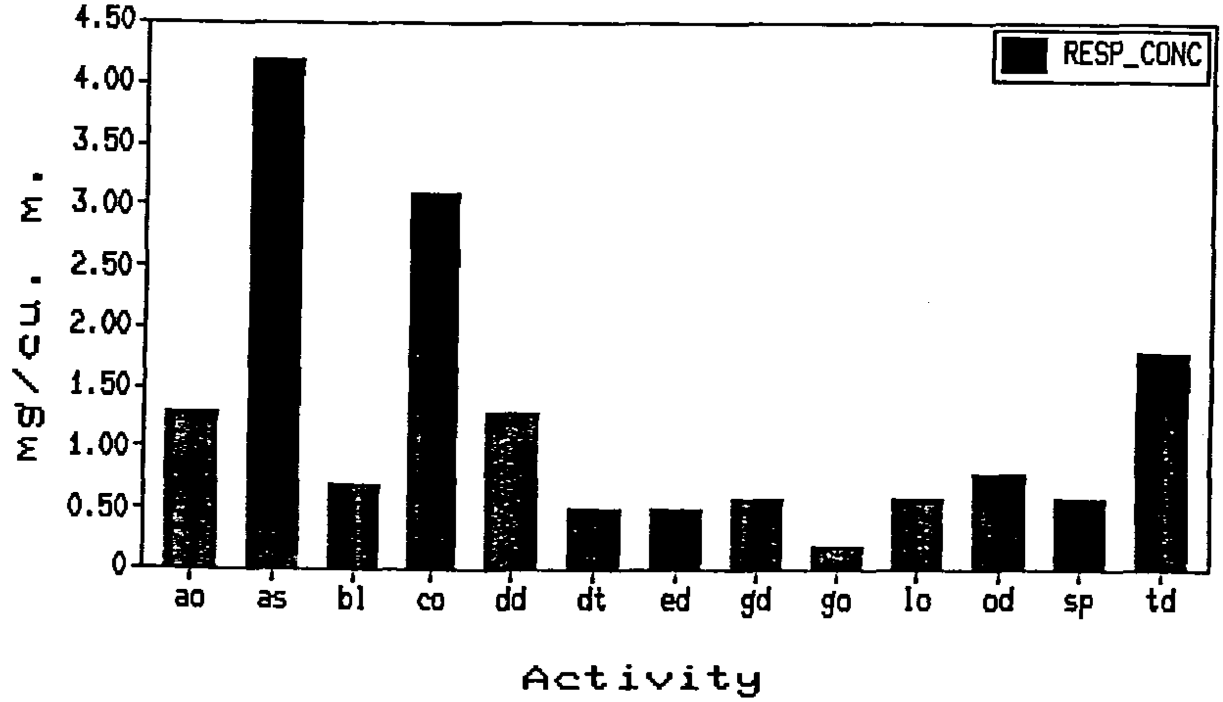


Table IV
Average Free Silica Concentration by Activity
(All Gold Mines Surveyed)

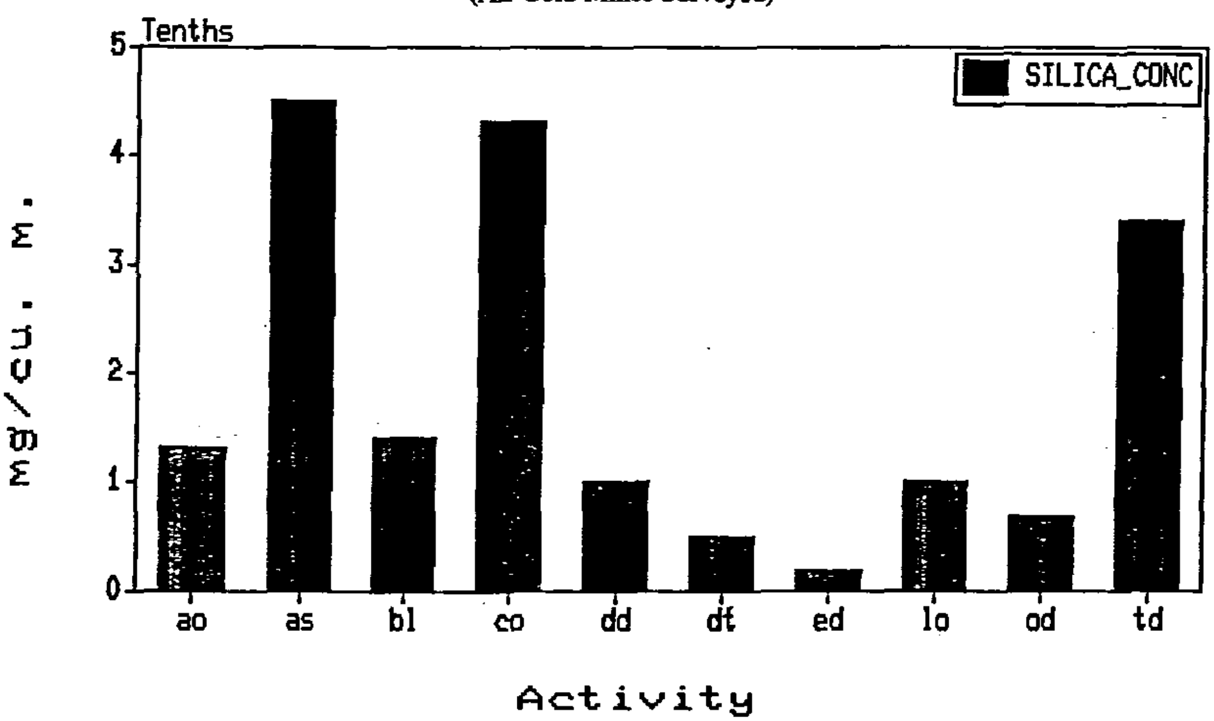


Table V
Average Respirable Dust Concentration by Activity
(All Quarries Surveyed)

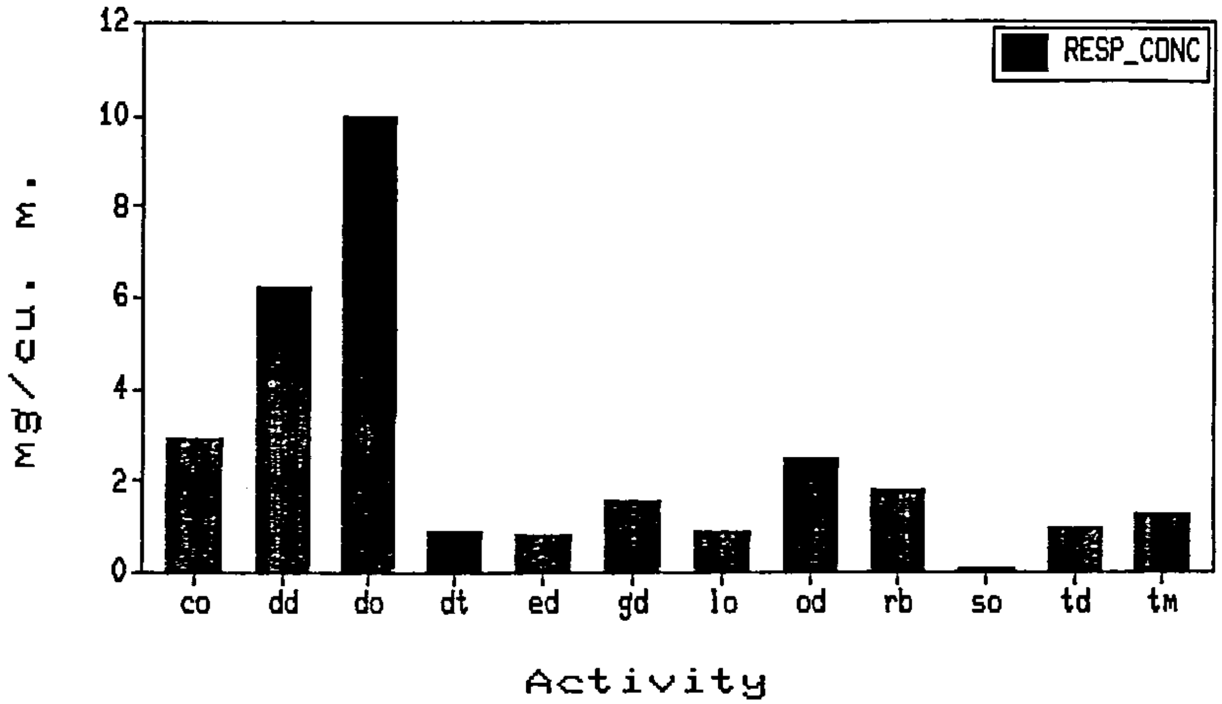


Table VI
Average Free Silica Concentration by Activity
(All Quarries Surveyed)

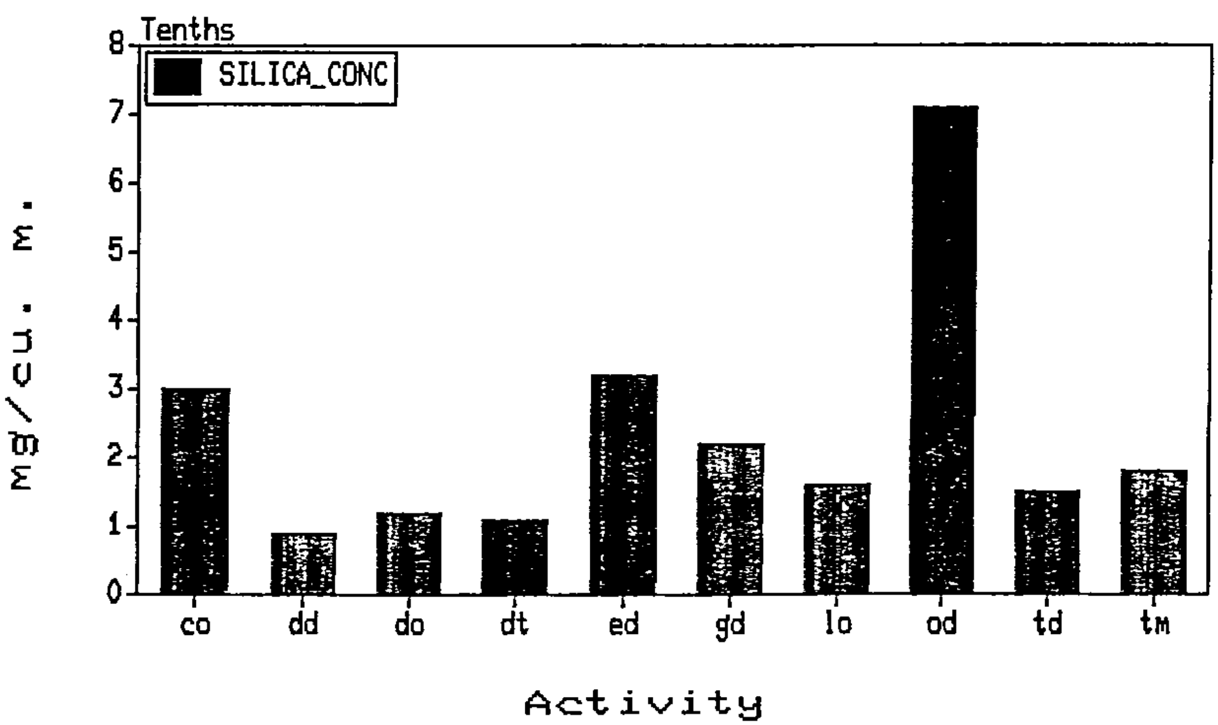
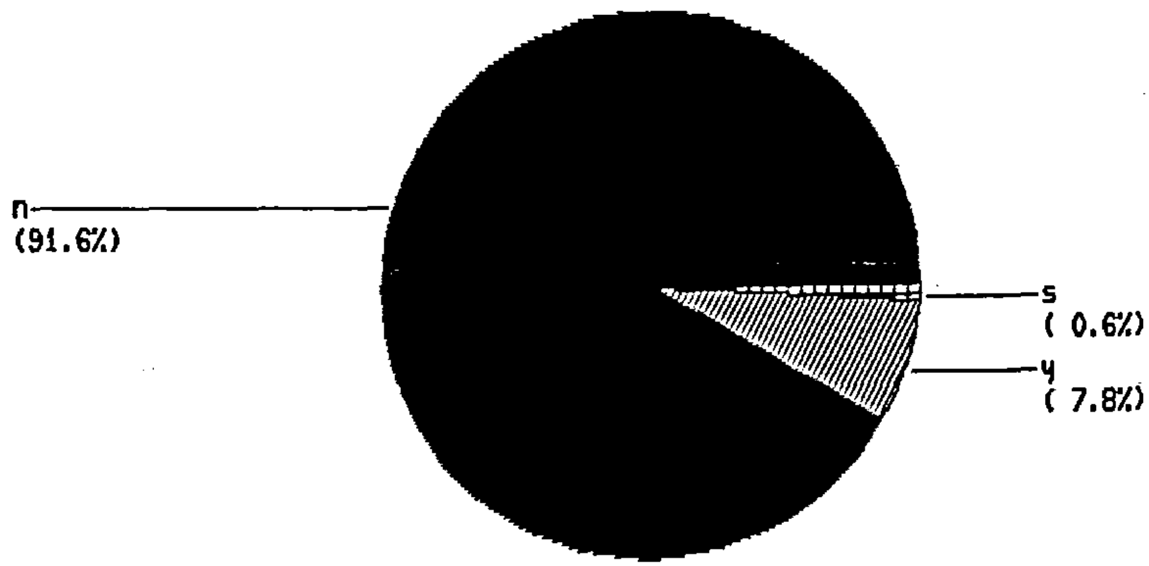


Table VII

Mask Usage
(All Metalliferous Mines Surveyed)



sampled, no respiratory protection was employed. This problem is now being addressed by SIMTARS with increased quartz monitoring to study quartz exposure by occupation by mine.

This survey represents the establishment of base respirable dust exposure levels in the Metalliferous Mining Industry which is in an expanding raw material resource economy. Compared with other hardrock mines within Queensland which have had the benefit of environmental and radiological surveys, a relatively greater problem exists in these more recently surveyed mines.

Pertinent data is being channelled to the regulating (Inspectorial) group within the Queensland Department of Mines. Some positive progress has been made in recent months with the installation of dust extraction systems on an errant crusher and several air track drilling systems. Impending occupational health legislative changes which will bring Queensland in line with the other Australian states should result in a more committed management safety philosophy.

Dust surveys of this nature will be carried out on an on-going basis. This information base will be continually updated and a series of annual reports will be produced which will demonstrate the efficacy (or otherwise) of this nascent hygiene management program.

REFERENCES

1. Grantham, D.L., Bell, S.L.: A decades experience with personal dust monitoring in Queensland's coal mines. Australian Journal of Coal Mining Technology and Research 1987; 18:1-20.

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