JERICHO PROJECT
AIR QUALITY ASSESSMENT
POSSIBLE PRESENCE OF ASBESTOS

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1. INTRODUCTION

In Appendix A of Section D, Jericho Kimberlite Characterization, Chrysotile was identified in some of the kimberlite mineral samples. Chrysotile is one of the three principal forms of asbestos found in bulk materials. The samples were analyzed very early in the project using X-ray diffraction at the University of British Columbia (UBC). Unfortunately UBC's mineralogist was not involved. The UBC mineralogist (Matti Raudsepp) says that is not possible to distinguish the lizardite group minerals from each other using XRD. Two other mineralogists contacted by the Tahera team have confirmed that a positive ID of chrysotile is not possible with XRD. Therefore, the serpentine may or may not be chrysotile.

This document reviews the air quality issues associated with asbestos.

2. CONFIRMATION OF PRESENCE OF CHRYSOTILE

Before an asbestos sampling/monitoring program is started the presence of asbestos should be confirmed. Samples at various locations in the mine should be extracted and sent to an accredited laboratory for analysis. There are several methods for analysing suspected asbestos samples. The following is based on material from the Agency for Toxic Substances and Disease Registry and from the National Institute for Occupational Safety and Health (NIOSH).

Phase Contrast Microscopy

Phase contrast microscopy (PCM) accurately assesses fibre exposure levels for fibres ≥5 µm in length and >0.25 µm in diameter. However, PCM cannot differentiate between asbestos and nonasbestos fibres. Currently, the standard method for the determination of airborne asbestos particles in the workplace is NIOSH Method 7400, Asbestos by Phase Contrast Microscopy (NIOSH 1994a). In NIOSH Method 7400, asbestos is collected on a 25 mm cellulose ester filter (cassette-equipped with a 50 mm electrically-conductive cowl). The filter is treated to make it transparent and then is analyzed by microscopy at 400–450x magnification, with phase contrast illumination, using a Walton-Beckett graticule. A fibre is defined as any particle with a length >5 µm and a length-to-diameter ratio of >3:1. Although the PCM method is relatively fast and inexpensive, it does not distinguish between asbestos and nonasbestos fibres, and it cannot detect fibres thinner than 0.25 µm. Consequently, this method is most useful for the analysis of samples that are composed mainly of asbestos, but only where a significant fraction of the fibres are large enough to be counted. If samples are grossly contaminated by non-asbestiform fibres, then transmission electron microscopy (NIOSH Method 7402) should be used for positive identification. For fibres greater than 1 µm in diameter, then polarized light microscopy (NIOSH Method 7403) may be useful in identifying polymorphs (NIOSH 1987). Concentrations are reported as fibres/ml or fibres/cm^3.

Consequently, an analysis by PCM indicating high fibre counts does not necessarily indicate the presence of asbestos. Likewise, low fibre counts by PCM can not conclude an asbestos free environment. PCM merely provides an index of the total airborne fibres present in a given size range. Because of the limitations of this technique, many consultants and public agencies now require the use of TEM for certain monitoring and clearance activities.

Polarized Light Microscopy

Polarized light microscopy is frequently used for determining the asbestos content of bulk samples of insulation or other building materials (see, for example, NIOSH Method 9002 [NIOSH 1989] and OSHA method ID-191 [OSHA 1994]). This method is useful for the qualitative

identification of asbestos and the semi-quantitative determination of asbestos content of bulk samples. The method measures percent asbestos as perceived by the analyst in comparison to standard area projections, photos, and drawings, or trained experience. The method is not applicable to samples containing large amounts of fine fibres below the resolution of the light microscope.

Other fibres with optical properties similar to the asbestos minerals may give positive interferences. Optical properties of asbestos may be obscured by coating on the fibres. Fibres finer than the resolving power of the microscope (ca. 0.3 µm) will not be detected. Heat and acid treatment may alter the index of refraction of asbestos and change its colour.

Electron Microscope Methods

Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) methods can detect smaller fibres than PCM and also fibre type, but fibre counting accuracy is unacceptably poor. This is a result of the small area that can be scanned at high magnification. Accuracy is more limited with long (>5 µm) fibres. NIOSH Method 7402, Asbestos by TEM, is used to determine asbestos fibres in the optically visible range and is intended to complement NIOSH Method 7400. Examination of a fibre sample by either TEM or SEM allows the detection of much smaller fibres than light microscopy, and so more thorough data can be collected on fibre length and diameter distribution. Of these two methods, TEM has greater sensitivity for small fibres, and is the most common method for measuring asbestos in ambient air or inside schools or other buildings. SEM analysis usually images fibres that are more than 0.2 µm in diameter because of contrast limitations, while TEM can visualize fibres of all sizes. In addition, most modern transmission electron microscopes are equipped with instrumentation that allows examination of individual fibres by electron diffraction or energy-dispersive x-ray analysis. This permits determination of the crystalline and elemental composition of the fibre. Thus, reliable distinctions can be made not only between asbestos and non-asbestos fibres, but also between different asbestos mineral classes (NIOSH 1994b). SEM may also incorporate energy dispersive x-ray analysis devices. Although TEM clearly provides the most information about a fibre sample, TEM methods are relatively slow and costly compared to PCM methods.

X-ray Diffraction

X-ray diffraction (XRD) refers to the phenomenon in which the atomic planes of a crystal cause an incident beam of X-rays to interfere with one another as they leave the crystal. Researchers can identify certain crystalline components of a given sample by comparing diffraction results to known values (such as those from the Joint Committee of Powder Diffraction Standard/International Centre for Diffraction Data).

X-ray Diffraction is used for the analysis of free silica, asbestos in bulks, for product identification and for the identification of crystalline phases in general. Where relatively pure forms of asbestos only occur, X-ray diffraction has been used (Goodhead and Martindale, 1969) but this method is unlikely to be practicable where a large number of different materials constitute the dust.

The main application of XRD is in the analysis of percent chrysotile asbestos in bulk samples. Antigorite (massive serpentine), Chlorite, Kaolinite, Bementite, and Brushite can interfere with the identification of chrysotile. X-ray fluorescence and absorption is a problem with some elements; fluorescence can be circumvented with a diffracted beam monochromator, and absorption is corrected for in this method. Note that a positive ID of chrysotile is not possible with XRD. Therefore the XRD method is applicable as a confirmatory method for identification and quantitation of asbestos in bulk material samples that have undergone prior analysis by PLM or other optical methods.

Recommendation

Given the uncertainty associated with the previous analysis, kimberlite mineral samples should be reanalyzed using a combination of methods. For positive identification of chrysotile, TEM should be used together with an optical method such as PCM. Even though chrysotile is identified at one location it may not be present at other. Therefore, during the life of the project, mineral samples should be analyzed on a regular basis.

3. AMBIENT GUIDELINES AND MONITORING

If it is determined that asbestos is present in the kimberlite mineral samples then sampling of the ambient environment should be done to determine if the concentration of asbestos exceeds ambient guidelines. The exposure limit accepted by the BC Workers Compensation Board and the US EPA is 0.1 fibres per cc for an eight-hour exposure. The Canadian threshold limit values (TLVs) based on the time-weighted average concentrations for a normal 8-hour workday or 40-hour work week, to which workers may be repeatedly exposed is 0.2 fibres (longer than 5 micrometers) per cubic centimetre of air. If the limit is exceeded, then mitigation is required. The mitigation can either reduce the generation of asbestos laden dust or protect workers through appropriate protective gear or through dilution by adequate air exchange.

To ascertain whether or not mineworkers are being exposed to asbestos concentrations of greater than 0.1 fibres per cc, an ambient sampling program is required. The greatest amount of dust will be generated at the mine face where drilling and blasting occurs. Sampling in this environment can result in high dust load, which can render the sample unsuitable for asbestos identification. Alternatively the sampling can be done at the air exhausts or other suitable locations. Sampling should follow a proper strategy such as the US EPA SOP#: 2015 "Asbestos Sampling" or as in the review of methods for sampling asbestos fibres (IPCS, 1986).

As recommended in the previous section, the most commonly used analytical methods involve phase-contrast optical microscopy (PCM) (in the workplace) and transmission electron microscopy (TEM) (in the general environment). PCM is resolution-limited and non-specific for fibre characterization. TEM overcomes both limitations (Dement & Wallingford, 1990).

For workplace sampling the most widely used method for the last 20 years has been the membrane filter method. Several attempts have been made to standardize the method and a recommended method for the determination of airborne fibre concentration by PCM (membrane filter method) has been published (WHO, 1997). In this method, a known volume of air is drawn through a membrane filter on which the number of fibres is determined using a phase contrast microscope. Special attention should be given to flow rates, sampling time, face velocity through the filter, and where, when and how to sample. Preference should be given to assessing individual exposure by personal sampling. The sampling strategy should be selected to yield the best estimate of an 8-h time-weighted average concentration. Excursions may be evaluated for regulatory purposes. If the purpose of the measurement is evaluation of control measures, other methods may also be used.

For sampling in the general environment the methods for sampling ambient air depend on the method of analysis, but generally involve filtering airborne particles from relatively large volumes of air using membrane filters. Strategies and sampling methods have been described by Rood

(1991) and reviewed in detail in the Health Effects Institute study of asbestos in public buildings (HEI, 1991).

If workers are in a low dust environment, then personal monitors can be used to estimate the exposure to asbestos fibres during a shift. Exposures above the guideline limit will necessitate protective gear or other mitigation.

It is unlikely that ambient concentrations of asbestos fibres outside the mine will exceed the acceptable exposure limit.

4. CONCLUSION

Additional analysis of kimberlite mineral samples should be done to determine whether or not chrysotile is present and in quantities to warrant further monitoring. If chrysotile is not present in quantities of concern, then periodic sampling should be carried out as the mine progress underground to ensure that sources of chrysotile have not been encountered.

If chrysotile is present, then ambient sampling should be carried out to determine if workers are subject to eight-hour exposure limits greater than 0.1 fibres per cc. If such were the case then mitigative measures such as protective masks, air exchange or dust control would be implemented. Because the presence of chrysotile may vary with the area being mined, the mitigative measure may also vary or not be required at the various locations.

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