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Chrysotile asbestos quantification in serpentinite quarries: a case study in Valmalenco, central Alps, northern Italy

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Outcrops of serpentinites are usually strongly fractured and cataclastic, and the rock can only be used as ballast. However, in rare cases, like in Valmalenco (Central Alps, Northern Italy), fractures are regular and well spaced, and the rock mass has good geotechnical quality, ideal conditions for the extraction of dimension stone blocks. The Valmalenco Serpentinite is marketed worldwide as dimension and decorative stone, with remarkable mechanical properties and pleasing colours and textures. However, the same area was once subject to chrysotile asbestos mining, in the form of discrete veins along the main discontinuities of the rock mass. For this reason, airborne asbestos contamination can occur during the extraction and processing cycle of the rocks, therefore it is essential to locate and quantify asbestos in the rock mass, to reduce as much as possible the exposure risk. The first step was a detailed geostructural survey of each quarry, in order to characterize the main discontinuities (orientation, spacing, linear persistence, opening, filling), with special attention to the identification of fibrous minerals. The surveys was followed by extensive sampling of massive rocks, mineralized veins and fillings of fractures, and the cutting sludge derived from diamond wire cutting. Preliminary qualitative XRPD was performed on all samples, while quantitative analysis was carried out on the most representative samples of the main rock mass discontinuities. On the other hand, XRPD is not effective in the identification of asbestos percentages of less than 2% by weight, and the accurate distinction among the various serpentine polymorphs (antigorite, lizardite, chrysotile) is very difficult (if not impossible) when they are simultaneously present, due to their very similar basic structure and the strong structural disorder. The same samples were then analyzed by SEM-EDS (fiber counting after filtration on a polycarbonate filter), for a better distinction between fibrous and lamellar polymorphs. A lot of minerals were identified in the mineralized veins: chrysotile, carbonates, talc, forsterite, brucite, chlorite, garnet (andradite), magnetite and sulphides. The quantitative XRPD and SEM-EDS analyses proved chrysotile percentages comprised between 11 and 100% by weight. On the other hand, chrysotile was never detected in the commercial massive rock. Considering the geostructural properties of the rock mass, the total asbestos content of the quarries is comprised between 0.23% and 0.02% by weight, very low percentages of no mining interest, classifiable as naturally occurring asbestos (NOA) occurrence. The SEM-EDS analyses also showed a slight chrysotile contamination close to the salvages of mineralized veins (in the form of chrysotile filled micro-fractures), for a thickness up to 5-6 cm. This study shows that the airborne asbestos exposure risk can be easily reduced by avoiding diamond wire or explosive cutting along the main mineralized veins, and by squaring off the blocks in the quarry (instead of processing plants). However, this study does not consider the possible asbestos occurrence in the form of micro-veins and micro-fractures, outside of the main discontinuities, and cannot be fully applied to highly fractured rock masses.