Advanced Medical Mineralogy Short Course: Part-I

Quantitative Aspects of Regulatory and Non-regulatory Asbestos Group Minerals

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Asbestos group minerals include regulatory (crocidolite, amosite, anthophyllite, tremolite, actinolite, chrysotile), and nonregulatory (richterite, winchite, fluoro-edenite, balangeroite, carlosturanite, gageite, arfvedsonite, magnesio-arfvedsonite) minerals. Accurate characterizations of chemical composition, morphology, structure, and defects are necessary in order to find out mechanism(s) of carcinogenicity of asbestos group minerals. Calculation methods of chemical composition are still under debate and assume no vacancies at any sites. Substitution(s) may cause deviations from the ideal chemical formula and wide variations in chemical compositions. There are surprisingly very low numbers of standards available for x-ray diffraction (XRD) characterizations. Detailed morphology of the asbestos group minerals show "bundles" which composed of many "fibers" and "fibrils", enhances the surface area to volume ratio drastically. Increased surface area and surface chemistry may increase reactivity of these minerals. Flexibility may also be inversely proportional to fibril width. These thin fibrils may cause proliferation and then chemical reactions. The cation sites to which solution would have access are M(4), the tetrahedral sites, and the A-sites in asbestos group minerals. In terms of the cations occupying the near surface sites, M(4) is nominally occupied by the B-group cations (Na, Li, Ca, Mn, Fe^{+2}, Mg) and tend to be a comparatively irregular coordination. The A-site has the most vacant site, when partially occupied, which may contain limited amounts of Na and K. This irregularity may change the structure, e.g., defects, grain boundaries, flexibility, and alteration habits changing surface reactivity. The C-cations (Mg, Fe^{+2}, Mn, Al, Fe^{+3}, Ti) are found in M(1), M(2), and M(3) octahedral sites. There may be more limited access to the M(2) site from the surface, but the other cation sites, M(1) and M(3), will not immediately come in contact with the environment but interact once dissolution has begun. The most carcinogenic asbestos riebeckite (crocidolite) has the least fibril width, comparing with other asbestos group minerals. Ca coordinated with water molecules as it has been observed in Ca-amphibole tremolite. These calcic type minerals may become brittle when they loose their water content decreasing tensile strength. This may affect the flexibility and hazardous potential. Therefore, detail morphological and chemical quantification of individual asbestos group minerals in micro- and nano-scale may help evaluate its true carcinogenetic mechanism(s), and consequently prevention and possibly treatment of related diseases. The Senate Bill 742 recently approved, but materials where asbestos is present in concentrations of 1% or less by weight are not included. The amount of fibers inhaled, in terms of weight percent and number, need also be re-evaluated by mineralogists.

Advanced Medical Mineralogy Short Course: Part-II

Quantitative Medical Mineralogy as Applied to Erionite Series Minerals

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Erionite was first found in Durkee, Oregon, USA, and was defined by Eakle in 1898. In 1987 and recently in 2011, IARC reported that there was sufficient evidence for its carcinogenicity in experimental animals. Additional evidence came when erionite fibers were found in the lung tissues of pleural mesothelioma cases from the three villages of the Cappadocia region of Turkey, where there is an extremely high level of mortality from malignant mesothelioma. In consequence, erionite has been listed as carcinogenic to humans. In 1997, erionite was elevated to series status and individual species of erionite-Ca, erionite-Na, and erionite-K have since been re-defined. Our re-calculation of Eakle's original result shows that, the mineral erionite was correctly characterized in terms of balance error (E%) and Mg-test. However, erionite in the medical literature has often been incompletely or incorrectly characterized throwing doubt on the results of the work. Thus, characterization guidelines have been established and a modified E% formula with the boundary conditions of +/- 10% along with the Mg-test (Mg<0.80) has been proposed for positive identification of erionite. Using these criteria, published data have been re-evaluated and re-classified as erionite-Ca, erionite-Na, erionite-K. For each type of erionite, a new mean formula has been computed. If data do not pass the E% and Mg-test, then reference to them in the literature should be disregarded. In some cases, different results have been reported for erionites from the same location by different authors. In these cases, if data do pass both tests but are characterized as from more than one type of erionites, then the mineral should be classified as undifferentiated erionite until there has been further clarification. Unlike other minerals, erionite requires a special attention from the mineralogical community to help establish its true carcinogenic properties. A data bank should be established at one of the mineralogical societies and new data must be evaluated rigorously before being accepted as new data. Data should be updated periodically and be available to the mineralogical research community. There have been biological experiments performed using these uncharacterized erionite specimens. Animal and cell experiments should be performed only with minerals that have passed the quantitative characterization tests. Since the positive mineralogical identification, both for single fiber and bulk mineral, is imperative, the proposed characterization guidelines should be followed closely.