

Analysis of erionites from volcanoclastic sedimentary rocks and possible implications for toxicological research

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ABSTRACT

Erionite occurs in volcanoclastic rocks and soils; in some villages in Turkey the presence of erionite in local rocks is associated with mesothelioma, a disease also associated with inhalation of airborne asbestos. Since volcanoclastic rocks containing erionite are widely present in the western U.S.A., there is a concern over potential health issues following inhalation of dust particles in these areas and thus there is a need to identify and quantify erionite particles found in air samples during hygienic investigations. Previous attempts to analyze the few micrometer-sized erionite particles found on air sample filters under transmission electron microscope (TEM) encountered difficulties due to electron beam damage. Recommendations are presented for accurate analysis by both energy-dispersive spectroscopy (EDS) and selected-area electron diffraction (SAED). Much of the work previously published to establish the crystal chemistry of erionite has involved the relatively large crystals found in vesicles in extrusive volcanic rocks. Analysis of these crystals gives a weight percent ratio of Si to Al in a narrow range around 2.7 (molar ratio 2.6), consistent with a unit-cell formula $Al_{10}Si_{26}$. In addition, the cation contents of these crystals generally meet the charge balance error formula for zeolites. However, erionites formed in volcanoclastic sedimentary rocks (tuffs) have very different Si:Al weight percent ratios, around 4.0, which is above the upper range for the analyses of the crystals found in vesicles. Analysis of many particles in samples from different locations reveal two other major differences between the erionites from the sedimentary situations and those found in vesicles. (1) The extra-framework alkali cation (Na, K, Ca) contents are lower than required for a stoichiometric balance with framework Al substitution for Si so that the cation charge balance error formula limits for zeolites are not met. (2) There is a large variability in measured cation contents from particle to particle from the same source as well as substantial differences in average compositions from different sources. However, sedimentary erionites cannot be termed a separate mineral species because the crystallographic data are consistent with erionite and new zeolite names cannot be proposed on the basis of Si:Al ratios alone. In addition to chemical differences between erionite from different sources, there are also morphological differences. By analogy with asbestos minerals, differences in composition and morphology may have implications for relative toxicity, and future research should include consideration of these aspects.

Keywords: Analysis, chemical (mineral), erionite, electron microscopy, medical mineralogy, zeolites