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Medical mineralogy as a new challenge to the geologist: Silicates in human mammary tissue?

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ABSTRACT

Medical questions surrounding the toxicity of "silica" and other silicon-containing materials introduced into the body can be answered only through use of microanalytical techniques that provide chemical and structural analyses of microscopic and submicroscopic particles. A useful approach to the study of minerals and other foreign substances associated with silicone breast implants is to use polarized-light optical microscopy to pinpoint the materials of interest in the tissue and to follow that observation with analysis by Raman spectroscopy. Silicone breast implants contain both the organic polymer silicone and particles of amorphous silica. We studied the breast tissue from six women who had silicone breast implants and from three controls who never had implants to address questions about post-implant alteration, such as to "crystalline SiO_2." Optical analysis of the mammary tissue sections revealed a variety of birefringent and non-birefringent, non-cellular materials. Raman spectroscopic analyses of those substances identified many similar materials in tissue from women with and without silicone implants: calcite, apatite, starch, lipid, and β-carotene. We also spectroscopically identified silicone (only in breast tissue from patients recognized to have had ruptured implants) and paraffin (only in one sample that had been embedded in paraffin and subsequently "deparaffinized"). In tissue sections of 5 μm thickness (standard thickness of pathology sections), it is impossible to detect optically the birefringence of quartz (or any other form of crystalline SiO_2), even though it may be possible to image such thin crystalline SiO_2 grains in polarized light due to light-scattering phenomena. Moreover, neither crystalline nor amorphous silica was identified by Raman spectroscopy in the tissue sections. Review of the pathology literature on such materials-based issues as silicosis and calcification revealed some misapplication of the optical microscopy term "birefringence" and misleading identifications of minerals in tissue sections. Our conclusion is that useful collaborations can be developed between (1) pathologists who observe foreign materials in tissue sections and understand the medical context of their findings and (2) mineralogists who routinely use optical, chemical, and structural analyses to characterize micrometer-sized crystalline materials and who understand materials properties.